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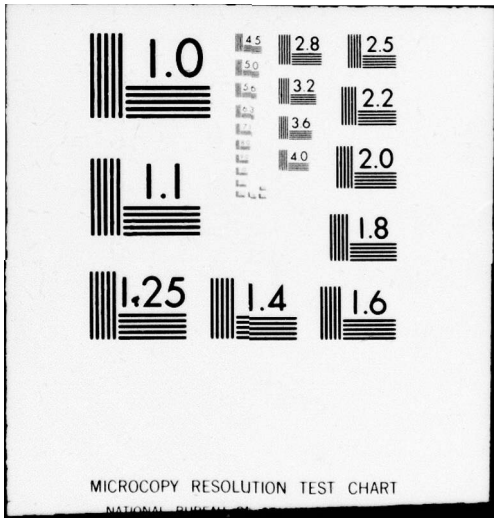
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of

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scientific staffs of the United States Air Forces' European Office of Aerospace and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

EUROPEAN SCIENTIFIC NOTES OFFICE OF NAVAL RESEARCH LONDON

I. Kaufman and Victoria S. Hewitson

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AVIONICS

ANKARA AGARD CONFERENCE ON AVIONICS RELIABILITY

The Avionics Panel of the NATO Advisory Group for Aerospace Research and Development (AGARD) held a conference in Ankara, Turkey during 9-13 April 1979. The Conference title was Avionics Reliability, Its Techniques and Related Disciplines. Forty-seven papers were presented in five major topic areas. Mr. Manfred Jacobson (AEG-Telefunken, Ulm, FRG) was Program Chairman. Mr, H.A.T. Timmers [National Aerospace Laboratory (NLR), the Netherlands], is Chairman of the Avionics Panel.

The Avionics Panel acknowledged the importance of reliability related disciplines to the process of acquiring effective military systems in the following remarks from their conference theme:

"The demand for higher avionics reliability and better maintainability is dictated by the requirement of flight safety in terms of tolerable hazard rates, mission reliability in terms of increased mission success probability, equipment availability in terms of reduced mean time to repair, and reduction of avionic support cost by savings in maintenance manpower, spares, test equipment, training, and technical data.

"There is a definite need for better adaptation of reliability related considerations to common engineering practices. The improvement of component and avionic system reliability must be accompanied by a commensurate emphasis on the optimal allocation of reliability according to the system complexity, the establishment of cost-effective specifications, qualitative and quantitative reliability analysis and testing to ensure achievement of specifications. The objectives must be clearly formulated in terms of responsibilities, procedures, methods, and standards.

"Regardless of the level of effort, the early influence of quality assurance including reliability engineering during design and development is essential in achieving avionics operational effectiveness determined by the two system parameters availability and capability."

In the General Concepts Session, considerable discussion centered around difficulties inherent in using existing government standard reliability prediction documents to predict reliability of avionics equipment. Representatives of several countries shared this concern. Models in existing documents need to be expanded to account for additional parameters considered to be important by engineers of avionics equipment. Other papers in this general session addressed problems in reliability growth, reliability modeling, parametric estimation for the 3-parameter Weibull distribution, and availability modeling for a network of communicating computers.

The second session contained topics on reliability and availability requirements, testing and demonstration. Several papers reported on new and practiced concepts of reliability warranty clauses. This concept allows for reliability improvement of developed hardware through contractor commitment to perform repair services at pre-established prices for a stated time. Initiated in the United States in the early 1970s, this concept is now being practiced in several countries. It appears to be a viable means to assure reliable and maintainable equipment at reasonable cost.

Excellent papers on the historical development of reliability improvement warranty (RIW) programs and case studies of such programs being practiced today were presented. From all of the papers given at this Conference, it appears that the RIW and related concepts are among the most effective tools for assuring that effective mean time between failures (MTBF) goals are met by the contractor. In this session two papers were presented on reliability demonstration and assurance testing. The concept of production reliability assurance (PRA) testing on all items for short testing times was discussed in terms of needed modifications of MILSTD 781 test plans for this type of testing. MILSTD 781 is a reliability testing/demonstration standard based on the exponential distribution of time to failure. Modified Corrective Action Required (CAR) lines from those established in MILSTD 781 under sequential testing procedures were discussed.

The third session pertained to reliability and maintainability practices on effects in avionics design, develop-

ment, and production. Papers addressed the impact of technologies selected on reliability, new maintainability prediction models, and environmental testing. An excellent paper made a case for use of emulation (as opposed to simulation) techniques to assess reliability of reconfigurable, highly reliable fault-tolerant computing systems for avionics. A principal feature of this paper pointed to the relative inaccuracies of mathematical models applied to fault tolerant systems with extremely high reliability goals. Inaccuracies inherent in the assumptions of the model may far exceed the relative accuracy of the reliability goal; e.g., $1-(0.1)^9$. Emulation techniques provide a tool to assess the time to assess detection of an introduced fault into a fault tolerant system. It also provides a failure effects analysis tool and can be used to generate repeated trials of emulated systems from which failure ratios and histograms are tabulated. Preliminary evaluation of experimental emulations have merited further study into emulation methods at NASA. There was also a paper on reliability of large scale integration (LSI) circuits in this session. The complexity of testing LSIs was noted, and the importance of designing LSIs to permit effective testing was discussed.

In the fourth session, five papers were presented on the evasive problem of software reliability. Papers were analytical and exemplary. The case history of the software development program for TORNADO, a multi-role combat aircraft, was presented. The methods and procedures that produced software of desired quality in this program were extensively discussed. Considerable detail was provided on software definition, writing, testing, and delivery phases of the program. The importance of software reliability in current and developing systems was evident to all countries represented. Its importance will only increase with increasing introduction of highly reliable microprocessor components in avionics systems. Several analytical papers were presented on modeling, assessing, and verifying software reliability. It was apparent that all attending countries are realizing the increasing importance of this subject, made complex in part owing to the creativity of the software developer and the inevitable misunderstandings associated with verbal communication between software developer and user.

The fifth and final session addressed topics in avionics logistic support. Excellent papers were presented that covered the importance of addressing logic support at the design stage, and identifying proper roles and responsibilities of logistic support personnel in the management structure. One paper described a procedure for the development of maintenance policies used in the TORNADO program. (W.M. Woods, Naval Postgraduate School, Monterey, CA 93940)

EDUCATION

THE UNIVERSITY OF NAVARRA, OPUS DEI

Between visits to the two Higher Technical Schools of Telecommunication Engineers in Madrid and Barcelona (*ESN* 33-4:144) I stopped off at the Universidad de Navarra, one of Spain's very few universities accredited but not established by the State, to see its Faculty of Information Sciences. The University is located on the edge of Pamplona, a city of 170,000 and capital of the 4000 mi^2 province (formerly kingdom) of Navarra. Although the city, located in the western foothills of the Pyrenees 20 miles from France, is perhaps best known as the setting of Ernest Hemingway's *The Sun Also Rises*, its annual Fiesta de San Fermín, with the running of bulls through its streets, lasts only from 5 to 15 July, and the rest of the year life there is quite normal.

The University is the first to have been established by Opus Dei (the work of God), an international Roman Catholic organization composed mainly of laymen created in 1928 by Mons. Josemaría Escrivá de Balaguer (1902-1975), chancellor of the University from its founding in 1952 until his death. It is supported by students' fees (though a large proportion receives aid), by the province of Navarre, by the Friends of the University, who now number over 20,000, and to some extent by the national government.

At present, the University has 7000 students in Pamplona and others on its campuses in Barcelona at the Instituto de Estudios Superiores de Empresa (School of Business Administration) and in San

Sebastián at the Escuela Técnica Superior de Ingenieros Industriales, which offers industrial, metallurgical, mechanical, and electrical engineering. The main campus in Pamplona has Faculties of Sciences, Pharmacy, Medicine, Architecture, and Philosophy and Letters as well as Law, Theology, and Canon Law. Although the great majority of the students are Catholic, admission is not restricted to Christians.

Teaching at the University is a full-time occupation, and professors are expected to take an interest in the students' extracurricular lives as well as in their studies, but the University does not seem at all monastic. Like all European universities, it has its bar and smoking is permitted everywhere. Faculty members do not have offices but, rather, desks in the appropriate parts of the University's well-stocked and well-equipped library stacks.

The Faculty of Information Sciences' library includes microfilm files of leading newspapers of the world and microfilm readers that can produce hard copies. This Faculty, in addition to regarding information from the viewpoint of journalism, is not without its electronic side. It has up-to-date fully-equipped radio and television studios, the latter linked by cables to a couple of classrooms so that TV films and programs can be seen there, but there is no campus radio or TV transmitter. Indeed, there is not even a daily or weekly campus newspaper. Students of journalism are expected to gain experience during their summer vacations. They do, however, learn at the University about the technological apparatus used in their profession.

My host during the visit to the University was Prof. Esteban López-Escobar, whom I had found listed as a Professor of Information Theory. He recently published a book *El Nuevo Orden Internacional en la Información* (The New International Order in Information) dealing with the effects of news agencies and international organizations upon the disequilibrium of information and, eventually, the national and international freedom of the press. The 45 members (approximately 35 of them with doctorates) of the Faculty of Information Sciences, under the deanship of Carlos Soria, have degrees in the fields of law, economics, history, languages, literature, sociology, etc., rather than in journalism, as the five-year program for the licentiate (first) degree stresses understanding the causes of significant events.

López-Escobar showed me through the University's Clinic, which functions not only as a teaching hospital but also as a regional center for medical care under Spain's social-security program, serving eight provinces. The Physiotherapy Department appeared to be beautifully equipped with the latest types of apparatus, as was the Radiology Department with its recently acquired axial tomograph.

In addition to a growing variety of specialized faculties, the University has an Institute of Liberal Arts, in which a hundred students from twenty countries are allowed to select approved programs of studies chosen from the offerings of the specialized departments. This Institute, representing an approach to undergraduate education like that in the US, does not grant the *licenciado* but, instead, the *bachelor* degree, upon completion of the program of studies and approval of a suitable thesis. The *master* degree is awarded at a more advanced level. These English terms are used despite the possible confusion with the Spanish *bachiller*, which signifies a high-school graduate. The University of Navarra awards a hundred doctorates annually as well as a thousand lesser degrees.

Members and supporters of Opus Dei hold many key positions in Spain's commerce, finance, communications, education, and government, and they at times constituted at least half of Franco's cabinet. The organization professes no political creed, but it exerted a great influence on Spain's development during the 1960s, and in Pamplona it has created a beautiful, smoothly running university that may come to have a wide influence despite its being off the beaten path. (Nelson M. Blachman, GTE Sylvania Electronic Systems Group, Mountain View, CA)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

MILITARY COLLEGES IN GERMANY AND THE UK: EXCELLENCE IN TECHNICAL EDUCATION AND RESEARCH

For the first verse of this song, readers are referred to the note by Nunn (*ESN* 30-4:157). The melody established there emphasized the excellence of the technical education programs at the new (1975) Hochschule der Bundeswehr (HDB) in Hamburg, the Technical University of the Armed forces of the FRG. (There is also a second HDB in Munich.) For readers who do not have ready access to Nunn's earlier note, it will be useful to review some of its main points in addition to presenting new material in this note, which describes programs both at HDB and at the corresponding UK institution, the Royal Military College of Science (RMCS) in Shrivenham, UK, in the famous Vale of the White Horse. Although my main mission in recent visits to HDB and RMCS was to discuss Materials Science research, I had the opportunity to take in the broader educational scene at both schools, so that this note will comment on both the research and the institutional structures.

In his article on HDB, Nunn, who, like this liaison scientist, is from the Naval Postgraduate School (NPS) in Monterey, CA, (which is a corresponding US institution), drew comparisons between HDB and NPS and, more significantly, between the national policies for technical education of military officers in Germany and the US. It is hoped that the information conveyed in this present note will allow further a comparison of HDB, RMCS, and NPS, as these institutions reflect the current situations in Germany, the UK, and the US respectively.

HDB: In 1972, the German Ministry of Defense decided on a drastic reorganization of the educational program for military officers, and a mere three years later, HDB Hamburg opened the doors of its first new building, which is quite a spectacular place in itself. (See Nunn's note for many further points about its facilities.) The decision to build the HDB's in Hamburg and Munich was based on a careful study of corresponding institutions in the US and UK, and the Germans have wisely retained the good and left out the bad parts of these systems.

Students come to HDB with an educational background that is roughly equivalent to upper division standing in a US university. They have been in the military service about one year, having in that time received all the necessary "gung-ho" training, and are then allowed to devote full time to academic education while at HDB (unlike West Point, Annapolis, etc.). The curriculum is truly streamlined, with a trimester system and graduation after three years with an Engineer's diploma, roughly equivalent to a Master's degree. (This is the usual five-year first degree in Germany.) The innovations in the pedagogical system are too numerous to mention them all here. The faculty are all civilian and have been recruited from the best German universities and (quite deliberately) from industry. The faculty is truly integrated, and perhaps the most remarkable innovation accomplished is that the rigid German institute system does not exist here. (See Technical Report ONRL R-18-75.) Also, unlike any other German university at present, HDB is divided into academic departments. [There is currently an initiative to do this throughout the Lower Saxony Province, which includes Göttingen, Hannover, etc. (see *ESN* 33-6:232).] The four departments are Electrical Engineering, Mechanical Engineering, Arts and Social Sciences, and Economics and Management, and degrees are obtained in one of three fields: Engineering, Management, or Pedagogics (!).

Officers who attend HDB are just beginning their military careers, and so attain the Masters level significantly earlier than in the US, where the average officer-graduate student may have forgotten a lot of his undergraduate schooling upon entering graduate school. Another key point about the German system is that the educational process does not impede the career pattern, for every officer who expects to go further must succeed at HDB. Also, graduating officers in Germany are not stamped with "codes" (as specialists in some field) in the way we do in the US.

As was Nunn on his visit to HDB in 1976, I was overwhelmed with envy when touring the splendid facilities. Simply stated, for both education and research, there is the latest and the best of everything. Furthermore (and more significantly), the system has also provided a support staff that is equivalent in quality and quantity to the facilities.

Materials Research at HDB: Materials research at HDB is carried out mainly in the Institut für Werkstofftechnik (Materials Technology), part of the Department of Mechanical Engineering. As mentioned, this is not a classical German university institute; it has three professors: Heinrich Kreye, whose specialty is physical metallurgy, T. Petzel, in solid state chemistry, and H. Hoffmeister, in welding metallurgy. There is no head of this Institute, an astounding contrast to the usual patriarchal structure of German research institutes and a reflection of the innovative approach to education at HDB. The staff of this informally organized institute includes three professors, two researchers with doctorates, three full-time and two part-time technicians (including a purpose-trained metallographer), and about ten students per year pursuing a specialty in metallurgy.

Physical metallurgy research encompasses a variety of problems, the most prominent of which relate to metallurgical aspects of various unique joining methods, including friction, cold pressure, ultrasonic and explosive welding. Bonding mechanisms are being studied, and some extremely impressive transmission electron microscopy has been carried out on weld interfaces. Weldability of metallic glasses is currently being investigated. Other topics of study include the early stages of decomposition of supersaturated solid solutions, particularly in spring alloy materials such as Cu-Be. The range of facilities for physical metallurgy research is stupendous. I don't believe I have ever seen a better equipped metallurgy laboratory from a quality standpoint.

While at HDB I also had conversations with Wolfram Funk, head of the machine element group in the Institut für Konstruktionstechnik, also part of the Department of Mechanical Engineering. Funk's area of interest is dynamic testing, as he is one of the original developers of the sophisticated computer-controlled Schenck servo-hydraulic testing machines, a line of equipment similar to MTS machines in the US. The facilities for dynamic testing of this sort are, as one would expect, quite impressive indeed.

RMCS: RMCS is responsible for the scientific education of the UK military officer at all stages of his career, and in this sense it is like a combination of West Point and a graduate institution like NPS, except that, as at HDB, military training has been removed. Uniforms are worn one day a week, probably to remind the students how to put them on. As in other British institutions of higher learning, the programs lead, in three years, to a standard UK undergraduate degree. This degree is probably better than the average BS in the US, but not quite to the Master's level. RMCS is also involved in quite a bit of later-career refresher course activities. There are 140 faculty members, i.e., 100 civilian and 40 military. The latter teach military specialist courses almost exclusively. Students at Shrivenham either work toward an Applied Science or an Engineering degree (metallurgy is in the former category here). Both degrees are awarded by the UK's Council for National Academic Awards, the body that awards degrees to students of British Polytechnics (not of Universities; see *ESN* 32-6:203). Students may remain or return for MS and PhD degrees, but these are almost entirely the civilian students.

Civilian students you ask? Yes, and to me the most outstanding aspect of RMCS's character and a most important factor to its stature is that it caters to both military and civilian undergraduate and graduate students. (NPS can accept civilian graduate students only if they are DOD employees.) This is possible because unlike the US, almost all institutions of higher learning in the UK are government funded, therefore a government-sponsored military-oriented university is allowed to accept students from the general populace on an equal footing with non-military schools.

Materials Research at RMCS: Materials research at RMCS is carried on in several different places, including the Chemistry and Metallurgy, Physics, and Civil Engineering Departments. Prof. J.A. Belk heads the Metallurgy Branch of the first of these. Belk recently taught a year at the Naval Academy in Annapolis on an exchange program and gave visiting lectures at NPS, so he is a useful point of contact for comparisons of the materials programs at the respective schools.

In the Metallurgy Branch at RMCS, as at NPS, students do not pursue a full course in metallurgy or materials, so

that the research is carried out mostly by support staff. The difference from NPS is that there is a support staff and, in fact, quite an ample one. These people hold the same sort of civil service grades as do those at regular government research establishments in the UK and include several very skilled researchers. In effect, therefore, RMCS is a unique combination of an undergraduate university and a government research establishment.

In addition to four professors, the Metallurgy Branch comprises 10 permanent staff members, reflecting a vigorous support staff situation. These personnel are provided by the government primarily for support of the education program (which implicitly includes a research program); none are funded by outside research contracts. The faculty are considered to have 30% of their time available for research activities.

Belk's major area of expertise is electron microprobe analysis and other methods of microstructural characterization, particularly as applied to alloy development problems. For example, he recently has worked on metallurgical problems related to the development of superplastic forming, especially for zinc-aluminum-magnesium alloys. Also in the Metallurgy Branch, Dr. M. Edwards is concerned with problems of marine gas-turbine alloys, particularly the effect of corrosion on mechanical properties, and with the use of intentional temper embrittlement of steels relative to fragmentation applications. One of the questions in the latter research is whether fracture toughness is a good guide to predict fragmentation, or whether microstructure must be evaluated. P. Peapell and G.R. Loosemore have recently embarked on a program to study aluminum-steel explosive weldments from a microstructure-mechanical properties standpoint (impact and tensile properties are being evaluated, not fracture toughness). There also is a residual expertise here in underwater welding, but the recently active program is now quite dormant. A. Doig is investigating the properties of quenched and tempered alloy steel plate as affected by various melting practices, including high quality air melting, electroslag remelting (ESR), vacuum arc remelting (VAR), and VAR + ESR.

In the Physics Department, Dr. P.J. Fydelor heads a very impressive program for the development of new polymeric materials for battery separators. Polymers for these applications must be tailored to the specific battery system. The primary technique being advanced by Fydelor and coworkers is graft copolymerization by irradiation, whereby hydrofolic monomers from solution are superimposed on a hydrophobic backbone (plastic sheet) during irradiation. The facilities at RMCS include a pilot plant that contains all except the actual irradiation step.

In the Civil Engineering Department, the primary interest of a group headed by M.A. Parker is fracture mechanics from an analytical point of view. Parker has recently embarked on a program focusing on the numerical determination of stress intensity factors for cracks emanating from holes in finite sheets and strip. This involves the modelling of the redistribution of pin loading that occurs during crack growth, with experimental verifications included in the program. Dr. Pauline Hodkinson in the same group is working on problems associated with the interpretation of experimental fracture mechanics data, such as R-curve determinations that are covered by an ASTM standard which (it is felt) may be too stringent in terms of its requirements for sample sheet thickness for legitimate results.

Comparisons: In order to be complete in these comparisons, one should include the US undergraduate military academies at West Point, Annapolis, and Colorado Springs, as well as the graduate program at the Air Force Institute of Technology in Dayton. Also, in the US there is a large component of graduate education for military officers carried out in civilian universities. This reporter is limited to comparing HDB and RMCS with each other and with NPS as a representative US institution, and with the US program for military education in general.

A first significant difference is that both Germany and the UK separate military training from all academic education. The US does this only for graduate education. Military commissioning immediately precedes academic education in both Germany and the UK and therefore doesn't interfere with attention to academics. Also, both HDB and RMCS combine to some extent undergraduate and graduate training at the same institution, making coordination of the programs easier. Of course, at HDB, as at other universities in Germany, the

programs are naturally integrated, since the first degree awarded in Germany (the usual five-year degree) is roughly equivalent to a one-year Masters in the US.

There also seems to be significant philosophical differences regarding the role of research. At both HDB and RMCS, research is clearly recognized as an essential part of the basic educational process, and this principle is supported with cash and people.

In the case of the materials research programs at HDB and RMCS, where I can make the best comparisons, the size of the materials programs at both these schools is substantially larger than at NPS, whether measured in terms of faculty, support staff, facilities, students, or the range of courses offered. However, it is in all but the first of these categories that the major differences exist. HDB has 2 metallurgical faculty and additional permanent staff of 7. The corresponding numbers at RMCS are 4 and 10. At NPS they are 2 and 1.

While HDB and RMCS thus clearly emphasize materials research to a greater degree than NPS, they do lack one very attractive feature of the latter: the eternally blue skies and mild climate of coastal central California. (Jeff Perkins)

FLUID MECHANICS

THE INSTITUT DE MECANIQUE IN GRENOBLE

The Institut de Mécanique in Grenoble is a laboratory associated with the Centre National de la Recherche Scientifique (CNRS) and is attached administratively to the Université Scientifique et Médicale de Grenoble. The director of the Institute is Prof. M.G. Lespinard. Activities there are organized into four groups, namely Hydrodynamics, under the direction of Prof. H.P. Germain; Hydrology, under the direction of Mâitre de Recherche of the CNRS G. Vachaud; Dynamics of Fluids, under the direction of Mâitre de Recherche of the CNRS Emil Hopfinger; and Mechanics of Continuous Media, under the direction of Prof. P. LeRoy.

The organization of the Institute as well as the activities of the Hydrodynamics group were previously described. (See *ESN* 31-8:300.) The present write-up will therefore deal mainly with the work of the group involved in Dynamics of Fluids that was not previously covered and that was described to me by Prof. Rene Moreau.

One section of this group deals with turbulence and transition and is involved with an analytic theory of homogeneous isotropic turbulence, turbulence in a stratified fluid, homogeneous turbulence in an electrically conducting fluid under the influence of a magnetic field, and a study of finely structured turbulence downstream of a grill where the average flow is undergoing a plane deformation. In one relevant experiment demonstrated to me, a vertically oriented cylindrical tank filled with water was rotated about its axis of symmetry, with the water rotating in rigid-body motion along with the tank. A small amount of dye was introduced near the top of the tank, so that turbulence which was excited by oscillating a horizontal grid in an axial direction in this water near the bottom of the tank could be observed. The resulting induced turbulence caused long streamers of dye to move out of the dye layer on top of the tank in a downward axial direction.

In a study involving flapping of 2- and 3-dimensional jets, the jets were caused to oscillate in direction by injecting the jet flow peripherally in a fluidic manner at the jet orifice. Though the 2-dimensional jet had a greater rate of spread when pulsed than when not pulsed, the round jet quickly reverted to the usual self-similar flow field within the dimensions of the experiment. (I believe that if the experiment were carried out in a larger chamber for the 2-dimensional case, the 2-dimensional jet would also revert to a self-similar flow field.) An attempt to study bursting in the turbulent boundary layer used a jet injected normally into the boundary layer from the boundary to model the burst; unfortunately, the real and the modeling phenomena are somewhat different.

With a local application for the mountainous region near Grenoble in mind, a tilt tank set up to model snow avalanches was demonstrated to me, and the researchers involved asserted that the avalanches produced in the laboratory were similar indeed to the real thing.

In an experiment on thrust augmentation it was found that a 30% gain in thrust could be obtained if the primary

jet were pulsed at 50% of the mean velocity; however, the energy involved in supplying this pulsing just about wiped out the gain in effectiveness.

Moreau is personally involved in magnetohydrodynamic studies of liquid metal flows as applicable to foundry practice. In this regard he has developed the use of a pinch field to gate flow of liquid metal in the foundry and has used high-frequency alternating fields for stirring and atomization in the foundry.

In joint work of Moreau with Prof. H. Brannover of Ben-Gurion Univ. of the Negev in Israel, a study of the feasibility of solar energy heating of a fluid and energy conversion via MHD power generation shows competitive efficiency as well as more than competitive capital costs compared to a more conventional system. Surprisingly, the fluid medium studied was a mixture of tin and water.

In all, approximately 200 researchers and technicians at various levels are involved in both fundamental and applied research programs at the Institut de Mécanique in Grenoble. (Martin Lessen)

INFRARED TECHNOLOGY

IR LASERS AT WORK

The modern campus of the Eidgenössische Technische Hochschule (ETH) in its beautiful setting on the outskirts of Zurich served as a most pleasant meeting place for the "Second International Conference on Infrared Physics." Nine of the twenty-two invited papers and six of the eighteen sessions were focused on research or applications of IR lasers. This report contains a review of four papers that involve diverse applications of IR lasers, e.g., laser surgery and laser machining.

A study of dielectric and metallic walled waveguides for the transmission of far infrared (FIR) laser emission was reported on by J.P. Creen (Centre d'Etudes Nucléaires de Fontenay-aux-Roses). This laboratory, where France's first nuclear reactor was built, is developing FIR lasers to be used in plasma diagnostics of magnetically confined fusion reactors of the Tokamac design. Because large laser probe beam displacements ($\sim 10^{-2}$ radians) will result from electron density gradients inside the reactor's plasma and because the laser-to-plasma separation will be tens of meters, the use of waveguides may be required to facilitate the diagnostics. In the experimental part of this study, particular attention was given to attenuation, depolarization, and detection efficiency at the guide output.

The main results of the theoretical portion of the study were: 1) large aperture, hollow dielectric waveguides have lower attenuation than metallic ones, and 2) the attenuation is very sensitive to the transverse dimension of the waveguide and to the wavelength, but only weakly sensitive to the guide shape and wall material.

The transmission properties of circular glass, circular brass, and square brass waveguides to the emission of an HCN laser (λ = 0.337 mm) were determined experimentally. Other variables included the waveguide diameter and the angle of incidence (defined as the angle between the waveguide and laser beam axes). Matching conditions between the beam and waveguide were achieved when the beam waist (position of minimum beam diameter) coincided with the waveguide entrance and when d/D is satisfied by $0.35 < d/D < 0.5$, where D is the waveguide diameter and d is the beam diameter as measured from the 1/e intensity points. Hollow circular dielectric waveguides were considered to be the most convenient because of their maintenance of linear polarization and low attenuation. Polarization was thoroughly altered in circular metallic waveguides, and it was observed that attenuation dependence on the angle of incidence is less for metallic waveguides than for dielectric ones. In an experiment with a 4-cm-diam., 11-m long hollow dielectric waveguide, the losses were found to be 1.6%/m for a zero degree angle of incidence.

A paper submitted after the Conference had begun on the effect of the intensive radiation from a CO_2 laser (λ = 10.6 μm) on the optical transmission of water aerosols at both the effecting wavelength and 0.63 μm was presented by V.P. Bisyarin (Institute of Radioengineering & Electronics, Moscow). The speaker discussed experiments that were conducted with the CO_2 laser, operated in both pulsed and CW modes, and with the aerosol both static and moving (to simulate the effect of wind). During the static experiments, the HeNe laser

beam was spatially coincident with the CO_2 laser beam, and during the wind influence experiments, the CO_2 laser was directed across the wind direction and the HeNe laser beam (always parallel to the CO_2 beam) was either on the windward side, coincident with, or on the leeward side of the CO_2 laser beam. The more important experimental parameters are presented in Table 1. The power density

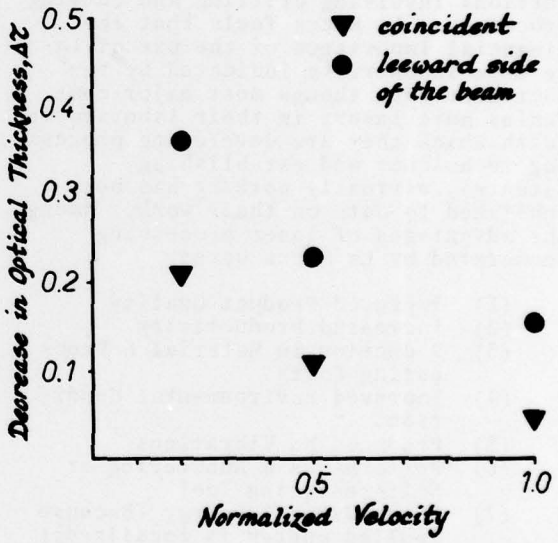
TABLE 1

CO_2 Laser Power (CW)	1 kW
" " Energy (Pulsed)	2-3 J/Pulse
" " Pulse Width	2 μsec
" " Beam Diameter	45 mm
HeNe " " "	5 mm
Mean Droplet Radius	3-5 μm
Maximum Droplet Concentration	10^4 cm^{-3}

of the CO_2 laser was sufficient to evaporate or explode the water droplets, and the resulting reduction in the droplet size is responsible for the change in optical transmission.

Experimental results were presented for three cases: 1) CW CO_2 laser, no wind, and transmission effects at 10.6 μm; 2) CW CO_2 laser, wind, and transmission effects at 0.63 μm and; 3) pulsed CO_2 laser, no wind, and transmission effects at 0.63 μm. For case 1), data indicate that for a CO_2 laser power density of 20 W/cm², fog clearing at 10.6 μm was nearly complete for an initial fog optical thickness τ_o of 1. (The optical thickness here is the thickness of fog for which the power density of the light passing through the fog has been attenuated to 1/e of the incident value. The subscript $_o$ refers to the condition before application of the laser pulse.) Much of the data presented by Bisyarin was expressed in terms of the decrease in optical thickness $\Delta\tau$, which is a complicated function of several variables, e.g., incident power, mean droplet radius, wind velocity, etc. The decrease in optical thickness $\Delta\tau$ was found to approach a constant value of 2.5 for values of $\tau_o \geq 4$. The saturation value of $\Delta\tau$ increases with increasing IR beam power density, and for a power density of 46 W/cm² the saturation value of $\Delta\tau$ could not be determined because the corresponding τ_o exceeds the maximum achievable in their fog chamber ($\tau_{o_{max}} = 6$). The saturation level corresponds to the maximum amount of water droplets that can be evaporated.

For case 2) the dependences of $\Delta\tau$ on wind velocity were determined for coincident and leeward positions (30 cm from the CO_2 beam axis) of the HeNe laser beam and for $\tau_o < 1$. These data are presented in the figure below.



THE OPTICAL THICKNESS DECREASE Δτ VS WIND VELOCITY

One can readily conclude that $\Delta\tau$ is greater on the leeward side and that $\Delta\tau$ decreases with increasing wind velocity. (The units for the velocity were not stated.)

For case 3) an abrupt decrease in the transmittance of the HeNe beam was observed that coincided precisely with the 3-J, 2-μsec CO_2 laser pulse. Transmittance decrease durations t_d were always much longer than the CO_2 laser pulse and values of t_d from 20 to 250 msec were observed in different experiments. A threshold value of 0.8 J/pulse was required to achieve droplet shattering.

It appears that the number of absorption/explosion events that a droplet and its fragments undergo and hence the resulting droplet size determine whether the transmittance of the 0.63-μm probe beam increases or decreases.

A.V. La Rocca (FIAT Auto S.p.A., Torino, Italy) presented an invited paper on "Machining with Infrared Lasers." In the context of his presentation, machining includes the following processes: drilling and deburring, cutting, welding, alloying, cladding, and surface hardening. The following review of his paper will focus on those portions involving drilling and cutting processes. La Rocca feels that the financial importance of the use of lasers in industry is indicated by the fact that even though most major companies have lasers in their laboratories (with which they are developing processing techniques and establishing patents), virtually nothing has been published to date on their work. Among the advantages of laser processing enumerated by La Rocca were:

(1) Improved Product Quality
(2) Increased Productivity
(3) Reduction in Material & Processing Costs
(4) Improved Environmental Conditions
(5) Produces No Vibrations
(6) Performs as a Nonwearing or Self-restoring Tool
(7) Saves Overall Energy (because applied energy is localized);

La Rocca pointed out the importance of using a flowing cover gas to remove the laser-produced plasma, which strongly absorbs the laser radiation. (When the formation of oxides is of no concern, oxygen can be used as both a cover gas and as a high pressure jet directed on the irradiated area.) This results in increased cutting and drilling speeds brought about by the exothermic reaction with most metals at high temperatures. Ruby and neodymium glass lasers are more commonly used for drilling as they can be better controlled in the pulsed mode than can CO_2 lasers. During drilling the laser induces a pressure shock which moves out of the hole at highly supersonic speeds. Pressure pulses of intensity close to 100 atm can be reached, and they are quite effective in removing fluid material.

Laser drilling in the heavy metalworking industry is too expensive, even with the use of oxygen as a cover gas. It is anticipated, therefore, that lasers will be used for final drilling of holes with small diameters, as in opening blind holes. Candidates for such drilling are: master cylinders, diesel injectors, and crank shafts. Table 2 presents results of drilling tests in a variety of materials.

TABLE 2

Material	Thickness (mm)	Single or Multiple Shot	Diameter (Max.) (mm)
Diamond	3	M	2.5
Diamond (synthetic)	3	M	5
Tungsten Carbide	3	M	4
Fine Grained Alumina	6	M	5
Stainless Steel	5	S	0.5
Ni/Cr Alloy	5	S	0.5

Laser cutting is accomplished by bringing a localized portion of the material to the melting point and removing the liquid with a jet of the cover gas. In laser cutting, a noble gas is usually used as the cover gas in order to avoid undesirable oxidizing and nitriding effects. However, when oxidization is of no concern, oxygen is used, as it greatly enhances the cutting rate. The use of the laser in cutting is particularly advantageous owing to the ease of automating the process and because complicated and previously impossible patterns can be followed. Advantages realized by laser cutting include: reduced scrap; lack of vibrations, dust, noise, and fumes; and elimination of the need of stocking and refurbishing a variety of tools.

It appears as though laser processing in industry has something for almost everyone: for the technologist—lasers can perform processes formerly impossible; for the environmentalist—reduced pollution; for the company stockholder—increased productivity; etc.

General comments on laser surgery and data on selected experiments with CO_2 laser scission carried out at the Univ. of Münster were presented by H. Dittrich (Department of Thoracic and

Cardiovascular Surgery, Univ. of Münster, Münster, FRG). Argon and neodymium lasers which penetrate the skin about 0.5 mm are used primarily for surface evaporation, whereas the CO_2 laser with its "skin depth" of only 0.05 mm is used for contact-free scission. As might be expected, upon comparing laser scission with scalpel and thermocautery scissions, one finds a mixture of good and bad news. On the good news side we have the following: Laser scission is the only cutting process that is essentially blood free, and experiments have shown that vessels up to 1.5 mm in diameter are sealed off. This is no mean advantage in that it makes surgery possible for the hemophiliac. In fact, it has been shown that blood loss in normal persons and hemophiliacs is the same for laser scission. Also, pain during and after laser surgery was found to be reduced. (This is conjectured to result from the melting of the nerve ends.)

Observations were made on the scarring, scar strength, and the nature and rate of healing of a large number of 2 cm long scalpel, thermocautery, and laser scissions on the backs of minipigs (a breed of small pigs). The melted necrotic tissue and the zone of thermally inactivated enzymes in the underlying tissue following laser scission is about one third that caused by thermocautery scission, and laser scission produces a cosmetically better scar than does thermocautery. Stress versus strain data for the three types of scission indicate that the differences in maximal stress are negligible when comparing laser and scalpel scars, whereas thermocautery scars averaged 30% larger tensile resistance.

On the bad news side, the tests performed on minipigs indicated that wound healing is two days longer with laser scission than scalpel scission. Also, scarring resulting from laser scission is a little worse than with scalpel scission.

The author was indeed pleased to hear not only of recent work on lasers, but also of IR lasers at work. Some years ago it was said by some that the laser was a solution looking for a problem. Even though there is an element of truth in that statment, it is obvious that the laser has been demonstrated to be a valuable problem solver.

Altogether there were 29 papers presented in the field of coherent optics. In addition to these, sessions were held on the following topics: spectroscopy, detectors, components and instruments, atmospheric transmission, atmospheric problems, and astrophysics. Persons interested in obtaining a copy of the Conference Proceedings (411 pages) can obtain one by sending SF 40 to: Proceedings, CIRP 2, Prof. Dr. Fritz K. Kneubühl, Solid State Physics Laboratory, ETH, Hoenggerberg, CH-8093 Zurich, Switzerland. (Richard S. Hughes)

MATERIAL SCIENCES

THE MALAYSIAN RUBBER PRODUCERS RESEARCH ASSOCIATION

In 1938 the British rubber interests in the Far East, principally in what is now known as Malaysia, established the British Rubber Producers Research Association (BRPRA) in Welwyn Garden City, just outside London. The purpose of the BRPRA was to conduct research on the production, processing and uses of natural rubber (NR) in an effort to increase production efficiency and generate new markets.

The BRPRA, organized by the late Sir Eric Rideal (*ESN* 28-10:392), was a novel concept for the time, being a nonprofit organization devoted to research for a specific industry. Moreover, the emphasis was (and still is) on basic research although direct consulting with both producers and users of NR has always been part of the function of the Association.

In the course of the "devolution" of the British Empire, Malaysia became an independent state in the late 1950s. Since part of the arrangement was that BRPRA would become the property of Malaysia it was renamed the National Rubber Producers Research Association. In 1970 it was renamed the Malaysian-RPRA, to reflect who pays the bills. MRPRA is currently part of the Malyasian Rubber Producers Development Board, located in Kuala Lumpur, which also umbrellas the Rubber Research Institute of Malaysia (RRIM) in Kuala Lumpur and the Malaysian Rubber Bureau, which is a collection of technical service offices around the world. The RRIM is a sister laboratory to the UK-based MRPRA, but the emphasis at RRIM is on the botanical aspects of NR production.

One of the most remarkable aspects of BRPRA/MRPRA is the parade of distinguished scientists that have been employed at one time or another by this organization. The list reads like a "Who's Who" in polymer and elastomer science. To name a few: L.R.G. Treloar, R.S. Rivlin, G.Gee, E.H. Andrews, E.G. Cockbain, C.M. Blow, A.N. Gent, A. Schallamach, and the late A.R. Payne. We can add to this list those who have made MRPRA their career: Alan G. Thomas, who directs the Physics Group and is also a visiting professor at Queen Mary College (London), and Dr. L. Mullins of Mullins Effect fame (the stress softening of rubber), who is the Director of Research at MRPRA.

There are probably two main reasons for such distinguished alumni. The Association management has always encouraged basic research without a demand that it be immediately relevant to the end use of NR. As a result the research has led to the discovery of a number of basic general laws on the properties of elastomers and polymers. A second reason is that MRPRA sees itself as a quasi-educational organization. It has ties to UK universities, and students use the facilities for their doctoral and postdoctoral research. Thus, the staff at MRPRA does not suffer the isolation from academic thinking that sometimes afflicts industrial research laboratories.

So why have so many good scientists left the MRPRA? One reason is professional visibility and another is money. The Association does not have the prestige of a university or of a large corporate research laboratory. Also, the salaries paid are not commensurate with industrial laboratories or universities (if consulting opportunities at universities are included).

We visited the Physics Group at MRPRA, where our host was Dr. Alan Roberts. The work of the Group is a strong mix of applied and basic research. Dr. C.J. Derham is determining the effect of rubber formulation on tire road-wear and performance on ice. In cooperation with the Univ. of California at Berkeley, Derham is developing rubber shock mounts for isolating buildings from earthquake forces.

Dr. G. Lake, of the Physics Group, another notable in elastomer science who, like Thomas, has been at MRPRA his entire career, has recently returned from a sabbatical in the US.

Roberts, a former student and coworker of Prof. D. Tabor (Univ. of Cambridge), under whom he investigated the adhesion and friction of rubber, is continuing this work at MRPRA. Studies of static and dynamic contacts between rubber and other solids have obvious significance to commercial products such as tires and rubber seals. However, this research is equally valuable in the fundamental study of intermolecular forces. Roberts has been a leader in this area and has recently written a comprehensive review paper [*Progress of Rubber* 41 121, (1978)].

The work done by Roberts, Tabor and others such as Dr. Brian Briscoe (Imperial College, Univ. of London) and Prof. Ronald Otteweil (Univ. of Bristol) is a fascinating and important area of surface science and is worth a few comments. They have observed the contact behavior of flat rubber discs through an intervening film of liquid. If the liquid contains ionic salts and/or surface active agents, electrical double layers form at the two opposite solid/liquid interfaces. As the two interfaces are brought closer to each other, repulsive forces develop between the opposing adsorbed films, and the magnitude of these forces depends upon the ionic strength and molecular configuration of the adsorbed layers. An equilibrium situation can develop where the force pressing the two solids together is balanced by the intermolecular repulsive forces. Much can be learned about surface double layers, so important to colloid and surface chemical phenomena, by measuring the equilibrium thickness of the stabilized liquid film and observing how it varies with changes in the electrolyte concentration or the type and concentration of the surfactant.

All of these studies are aided immensely if the rubber is in contact with a transparent solid, e.g., glass or clear plastic, so that the area of contact can be viewed optically. Then interferometry can be used to determine the thickness of the intervening liquid film. In studies of the sliding of rubber over another solid with an intervening liquid, the liquid film under the slider develops a characteristic profile owing to the pressure differential. Interferometry can be used to determine this film profile.

The most exciting work in these studies has been the determination of adhesive forces between rubber-solid

contacts (no intervening liquid). In these experiments the rubber, usually in the form of a hemisphere, has a very smooth surface since it is formed in polished metal molds. When the rubber contacts a glass surface under zero load the rubber is pulled spontaneously against the glass. Measurement of the attraction by using sensitive transducers gives a direct measure of intermolecular forces. This simple experiment and its many possible modifications offers much for the study of solid-solid interactions.

Currently, Roberts is investigating the sliding friction of rubber on ice. He is finding normal behavior below -10°C, but between -10°C and 0°C anomalous effects occur which, at this stage of the work, he thinks may be due to the presence of a liquid-like (Faraday) layer on the ice above -10°C. The existence of a liquid layer on ice has been repeatedly questioned since first proposed by Faraday in 1859. None the less, anomalous behavior such as Roberts is finding have been reported from time to time.

Roberts is also looking at the rolling friction of steel and glass on rubber at very high and very low rolling speeds. In one experiment the rubber is transparent and forms the inside floor of a squirrel cage. Glass and steel balls roll on the rubber as the cage rotates. Some interesting effects are observed when the area under the ball is viewed microscopically through the rubber. Notably, he observes Schallamach waves that result when adhesion between the ball and rubber causes buckling of the rubber surface to generate "waves of detachment" which rapidly transverse the contact region. Roberts is especially interested in the effect of relative humidity on this type of rolling friction in that it will tell him how adsorbed water affects adhesion between rubber and other solids.

Dr. K.N.G. Fuller, also a former student of Tabor, joined MRPRA to work with Roberts on the viscoelastic behavior of NR. The processing of raw rubber is characterized by a property called "nerve," which, simply stated, is a recovery after flow. As this property cannot be modeled by linear viscoelasticity, Fuller is trying to develop a nonlinear theory to handle it.

Sir Eric's concept of a central research organization to serve an entire industry has fared well in the BRPRA/MRPRA. Similar organizations have come into existence since BRPRA was formed but have met with variable success. Enlightened management has, over the years, fostered high quality science and has prevented the Association from becoming a test laboratory subservient to the industry. The parade of scientists through the Associations is likely to continue; the basic reasons for the staff eventually to seek more attractive positions still exist. However, neither the scientists nor the MRPRA seem to have suffered. (Willard D. Bascom)

GLUING IT UP AT CITY UNIVERSITY

Strictly speaking, the science of adhesion is concerned with the manner in which two solids or a solid and a liquid cling to each other through molecular attraction. In actual fact, people working in the field deal with the adherence of one material to another regardless of whether this is caused by intermolecular attraction or an intervening "glue" layer. Thus the science of adhesion has come to include such topics as polymeric adhesives (glues), the self-welding of surface-oxide-free metals brought together in high vacuum, and the adhesion of cells in biological systems, to mention only a few. Clearly, the field is interdisciplinary, involving surface science, polymer science, mechanics, physiology, etc. Because adhesion phenomena are so pervasive, there is a demand for scientists and engineers schooled in the subject. However, because of its interdisciplinary nature, few colleges offer a specific course or curriculum in adhesion science. The subject may be treated in a surface chemistry course, organic adhesives may be discussed in a polymers course, and adhesive joint design may find its way into a mechanical engineering curriculum.

So it was rather surprising to find an MSC course in Adhesion Science and Technology being offered jointly by the Department of Chemistry of the City University (London) and the National College of Rubber Technology in the Polytechnic of North London. The course is conducted by Mr. K.W. Allen of City University and Dr. D.W. Aubrey at the Polytechnic. The curriculum includes courses in surface science, polymer

chemistry and physics, the mechanics of adhesive joints, adhesion theory, and bonding technology.

Allen is no stranger to adhesion science and technology. He is perhaps best known as the organizer of the annual *London Conference on Adhesion and Adhesives*, the 17th of which was held on 27-28 March 1979. The presentations at most of these conferences have been published as the series, *Aspects of Adhesion*, edited by Allen. The series ran through Vol. 8 until the title was changed to *Adhesion*, of which Vols I-III have appeared thus far. Most of the volumes in these series contain papers from more than one conference.

The conference tends to be technologically oriented, with emphasis on bonding problems rather than the theory of adhesion. Nonetheless, the scientific quality, albeit applied, has generally been high.

Allen has been joined at City University by Dr. William Wake. Wake is "retired" from the Rubber and Plastics Research Association (RAPRA), and although in less than the best of health, he is much involved in the research at City and in private consulting.

Wake has recently completed a study of the microstructure of epoxy polymers. For many years it has been suspected that these polymers are not continuous, cross-linked networks but actually have a microstructure of highly cross-linked nodules a few hundred angstroms in diameter surrounded by a matrix of lightly cross-linked polymer. Scientists in the US, notably Prof. J. Koutsky and his coworkers at the Univ. of Wisconsin, have used electron microscopy to observe just such nodular structure on acid etched surfaces.

Wake has similarly observed this nodular structure and feels he was "scooped" by Koutsky. However, Wake feels he has gone further than the Americans by identifying a primary nodular structure and a secondary structure of nodular aggregates. He believes that the condition under which the epoxy is cured affects nodular aggregation and thus the mechanical properties of the polymer. For example, post-curing by heating above the initial cure temperature increases the degree of aggregation, which increases the fracture energy but not the tensile strength or modulus.

Wake and Allen are currently working on problems of adhesive bond durability. Under a contract from the National Institute of Neurological and Communicative Disorders and Strokes (National Institutes of Health, Bethesda, MD) they are investigating the bond between polysiloxane, rubber, and alumina. This is in connection with silicone rubber encapsulation of microelectronic devices used as body implants. Needless to say, no moisture should get into the device, but there is some concern that water will diffuse along the rubber/alumina boundary. Indeed, bonds between polymers and metal or ceramics are notoriously sensitive to intrusion and eventual debonding by water. The intent of the work at City University is to determine the mechanisms of water diffusion along the boundary and what can be done to reduce the diffusion rate.

In a related study, Wake and Allen are investigating the "coupling agents" used to improve the moisture resistance of polymer/glass and polymer/metal bonds. These agents are organofunctional trialkoxysilanes and commercially are called "silane" coupling agents. The simplistic view of their action is that the alkoxy moity is hydrolyzed and the resulting silanol group chemically bonds to the hydroxyl groups on the glass or metal oxide. The organofunctional end of the molecule, usually an amine or glycidyl ether group, reacts with the polymer. Actually, it is generally recognized that these agents react with themselves to form a thin polysiloxane network on glass or metal, and in some fashion this network reacts and/or is penetrated by the polymer. Beyond this it is unclear how the silanes improve bond durability. By forming free films and examining them using infrared spectroscopy and other analytical techniques Wake and Allen are trying to determine the molecular structure of the polysiloxane layer. They recognize that it is problematical whether the free films accurately simulate the polysiloxane networks that form on glass or metal surfaces.

In a new program just underway, Allen is investigating the effect of environment, heat and water on the cyclic fatigue endurance of polymer-metal adhesive bonds. It has been shown by a number of workers, notably Dr. Armond Lewis (Lord Corporation, Erie, PA), that below a critical number of cycles, adhesive joints of aluminum bonded with epoxy polymer exhibit no loss in strength. Fatigued beyond this endurance limit, some specimens fail and those that do not fail show

a loss in strength. Evidently, there is some induction period before the bond suffers any detectable damage. Allen hopes to determine the reason for this induction period and the effect of water vapor on the endurance limit. (Willard D. Bascom)

AN INTERNATIONAL CONFERENCE ON SOLID-STATE PHASE TRANSFORMATIONS

The recent International Conference on Solid-State Phase Transformations, held in York, England (4-6 April 1979), was the first of such wide-ranging meetings in more than ten years and was welcomed with great expectations. It was sponsored by the Institution of Metallurgists and the Metals Society, both of the UK, and attracted more than 150 delegates from a dozen or so countries.

A phase is usually defined by metallurgists as a structurally unique constituent of the microstructure, i.e., a region or regions with a given crystal structure, including exact specification of the lattice parameters. Therefore in metallurgical usage the concept of a phase transformation (PT) simply implies that changes take place in the spatial configurations of the atoms (i.e., the crystal structure) and/or the chemical composition of regions of the microstructure. Because of the wide variety of atomistic mechanisms by which such changes can occur and corresponding variations in reaction kinetics resulting in microstructures and properties as a function of numerous variables (notably temperature and deformation history), PT research is one of the most exciting metallurgical fields of study. It is full of constant surprises, often requiring the deductive skills of a Sherlock Holmes, and this conference reflected the usual intrigue of the field. In addition to the fascination that attracts many researchers, one can argue that PT studies are the means by which physical metallurgists are trying to develop practical "heat treating" into a science. In other words, one may be able to develop a new heat treatment that produces a stronger steel without actually knowing the details of the mechanism by which the properties are changed, but if a knowledge of the mechanism is acquired, one will certainly be in a better position to control and optimize the properties.

The Conference provided an excellent program of overviews by prominent researchers in the field and a selection of the best current work, although I suspect that historically it will not be regarded as much a landmark as were the 1955 and 1968 conferences. Several of the "big names" in the field were not in attendance, and the international balance was drastically skewed toward the UK (about 80% of the program), with surprisingly little contribution from three countries that are quite active and influential in the field; namely, Japan, Germany, and the US.

The Conference was divided into about 10 sections, with invited overviews used to keynote each. These were prepared by J.W. Edington (Univ. of Delaware) on new techniques for PT research; H.I. Aaronson (Michigan Technological Univ.) on diffusional transformations; G.W. Lorimer (Univ. of Manchester) on precipitation in non-ferrous alloys; R.W.K. Honeycombe (Univ. of Cambridge) on ferrous transformations; W. Gust (Univ. of Stuttgart, West Germany) on discontinuous precipitation; M. McLean (National Physical Laboratory; Teddington, UK) on morphological instabilities; R.A. Buckley (Univ. of Sheffield) on order-disorder reactions; C.M. Wayman (Univ. of Illinois) on martensitic transformations; R.J. Brook (Univ. of Leeds) on transformations in polycrystalline ceramics; and T.I. Barry (National Physical Laboratory, Teddington, UK) on transformations in glassy ceramics. There were also two technology oriented sections, one on processing the transformation characteristics of commercial materials; and the other on case studies that demonstrate how PT research has contributed to the development of successful commercial materials. In addition, there was a poster session and a memorable evening discussion dealing with microstructural nomenclature.

In phase transformations, the phenomena of most interest frequently occur on a very fine scale, so that advances in PT have generally followed the successive development of new higher-resolution techniques of investigation. The York Conference will perhaps be remembered as the PT conference of high resolution techniques that are now being

used widely to develop impressions of transformation morphologies. In his review of advanced techniques, Jeffrey Edington showed that although a wide range of experimental techniques have been used, the most useful are those that combine quantitative measurements of composition and crystallography with direct microstructural observations. Electron-beam based methods have been the most successful and currently are used widely. Edington emphasized electron microscopy techniques, including such procedures as quantitative x-ray microanalysis, electron energy loss spectroscopy, convergent beam microdiffraction, and weak-beam technique. The capabilities of Auger electron spectroscopy and the atom-probe field-ion microscope (AES) were also reviewed. He emphasized that the techniques tend to be complementary, i.e., no single technique will give all the needed information one needs; several techniques may often be used to develop a complete microstructural-crytallographic-compositional impression of the material under study.

The complete arsenal of techniques will cost an arm and a leg, but with it one will be able to obtain diffraction patterns and crystallographic information from regions as small as 2 nm, detect very small lattice strains (10^{-4} nm), do chemical analysis on regions as small as 50 nm, detect microsegregation, image lattice planes directly, analyze a 1% surface monolayer, and many other amazing feats. Readers who wish further insight into the basis and contemporary metallurgical applications of these techniques may be interested in two earlier notes (*ESN* 32-2:65 and *ESN* 32-10:351).

In a support paper Paul Butler (Imperial College of Science and Technology, London) described special methods developed to study phase transformations directly in the electron microscope, utilizing hot-stage equipment to transform specimens while being observed and recorded. (Bernstein has recently reported on other aspects of this *in situ* work at Imperial—see *ESN* 32-10:349.) Gordon Lorimer (Univ. of Manchester) reported on applications of quantitative analytical electron microanalysis, a subject that was the focus of a two-day meeting held at Manchester immediately before the York Conference. The main application emphasized by Lorimer was partitioning of alloying elements in steels during the pearlite transformation.

There were also papers from groups at both Oxford and Cambridge, who have been independently developing the atom probe for PT studies. The atom probe is an instrument based on the field-ion microscope and is a microanalytical tool of ultimate sensitivity, in that one can identify single atoms. Furthermore, the depth profile of composition from the sample surface inward can be aquired by successive field evaporation of the surface, and one can also display the lateral distributions of composition over the surface by developing a so-called field desorption image. Therefore the technique is particularly suitable to the study of the very early stages of phase transformations. The work of the Cambridge group was exemplified by an excellent presentation by Sally Hill on order-disorder transformations in Ni-Al alloys, using primarily the depth-profiling mode; while the Oxford work, reported by George Smith and coworkers, has been applied to the chemical analysis of individual small precipitate particles as well as to ordering reactions and other transformations.

Hubert Aaronson (newly appointed R.F. Mehl Professor of Metallurgy at Carnegie-Mellon Univ., Pittsburgh), in his keynote paper on diffusional transformations, described his most recent results in pursuit of agreement between experimental data and models for growth kinetics, especially for grain boundary ferrite plates in Fe-C alloys. He also considered the subjects of interfacial structure and the role of shear in certain precipitate growth cases. Both of these are quite controversial contemporary topics and will certainly be given much further study, perhaps with the assistance of some of the aforementioned new techniques.

Lorimer's review of classical precipitation reactions in nonferrous systems emphasized spinodal decomposition and included descriptions of transformations in mineral systems. Lorimer explained that the interest in these terrestrial minerals was inspired by the concentrated lunar rock studies that grew out of the US moon flights, by which methods applying advanced techniques were developed.

Ferrous transformations are the most technologically significant category of PT. Transformation from the

high temperature austenite phase to ferrite, pearlite, and other low-temperature phase mixtures occurs in millions of tons of steel each week throughout the world; and we now have, as a result of extensive research over the years, a reasonable understanding of the transformations. Honeycombe's keynote paper (presented by P.R. Howell of Cambridge) emphasized studies on the effect of alloying elements (elements other than Fe and C, the basic components of steels) on the important reactions. There were also a number of related support papers from his ferrous group at Cambridge.

Gust presented an amazingly thorough (460 references) review of discontinuous precipitation in binary reactions, while Buckley pointed out that order-disorder transformations are perhaps more difficult to study than other modes of PT. His paper emphasized work at Sheffield on Fe-Co alloys, using x-ray diffraction, transmission electron microscopy (TEM), and other techniques, with detailed studies of antiphase boundary morphologies and microstructural modes of the process of ordering as a function of temperature, annealing, cold work, quenching, etc.

The word "morphology" by dictionary definition includes both the structure and shape of things, but as used by metallurgists refers only to the shape of phases, without reference to crystal structure within these shapes. (For a total microstructure, the "morphology" refers to the size, shape, and spatial distribution of all the phases, i.e., to how it looks.) Morphological instability in microstructures refers to transformation phenomena (such as dissolution of phases, coarsening, change of phase shape, etc.) by which metastable structures evolve toward a lower energy equilibrium state. These changes are often quite undesirable because of the changes in material behavior involved (except in certain instances, such as hot working, in which it is desirable for the structure to change quickly to a workable state). The importance of the subject was emphasized in a recent symposium sponsored by the Institution (see *ESN* 33-3:106) and, of course, in the review given by McLean at this Conference. His analysis was essentially phenomenological, with no consideration of interface structures and such. Using mass transport analysis, he considered cases such as particle coarsening and breakdown of lamellar or rodlike morphologies in aligned eutectic microstructures. He also made a distinction between intrinsic instabilities that are driven by free energy changes resulting from a reduction in defect density in the material and intrinsic instabilities driven by external forces such as temperature and stress gradients.

Martensitic transformations have their primary importance in connection with the development of high strength in steels, although there are also martensites formed in numerous nonferrous alloys. Wayman's review was biased toward work in nonferrous systems, and included discussion of pre-transformation phenomena, nucleation, crystallography and morphology (backed by an excellent film of thermoelastic martensitic growth), the shape-memory effect, and recent studies on transformations crystallographically similar to, but not (by pure definition) actually, martensitic. In this last category, for the example of the transformation of vanadium-hydrogen solid solution to vanadium hydride, Wayman presented perhaps the first proof of a case in which both shear and diffusion are involved in the transformation mechanism.

Some other interesting contributed papers at the Conference included an impressive study of a sequence of phase transformations in Zr-Ti alloys by S. Banerjee (Bhabba Atomic Research Center, India), an interesting *in-situ* study of martensite nucleation by J.W. Brooks and coworkers (Univ. of Birmingham), work on ferrite-to-austenite transformation (reverse to the direction usually studied) in a stainless steel by P.D. Southwick (Univ. of Cambridge), early growth kinetics studies of plate precipitates in aluminum alloys by R.D. Doherty (Univ. of Sussex), interface phase transformations in α:ρ titanium alloys by C. Hammond (Univ. of Leeds), microanalytical studies of austenite decomposition by R.A. Ricks and coworkers (Univ. of Cambridge), precipitation reactions in ferritic steels by A. Hendry (Univ. of Newcastle), and martensite morphology in rapidly solidified ferrous materials by B. Canter (Univ. of Sussex). The session on industrial processing included papers related to aluminum alloys, steels, and superalloys, and the case histories sessions included

reports on the development of ultra-high-strength steels, TRIP (transformation-induced plasticity) steels, and shape-memory alloy devices.

On the whole, the York Conference was certainly a memorable one. It illustrated that in the ten years since the last PT conference dramatic advances in techniques have been made, and the theme emphasized throughout the Conference was the importance of structural and compositional observations. Numerous papers were keyed to the use of sophisticated high-resolution techniques for direct study of phase transformation mechanisms, sometimes directly at the atomic level, and these studies are leading to the replacement of some of the classical phenomenological models for phase transformations with detailed mechanistic descriptions. Another interesting aspect of this conference, which tends generally to be true of PT meetings, is that microstructure properties studies were not very visible, which may seem surprising in view of the key goals of detailed PT characterization. In fact, the York meeting probably did much better than previous meetings in addressing the vital research/technology crossover in the PT field, with help in this vein given by a healthy level of participation from an active industrial contingent in the UK. The Conference confirmed that the study of phase transformations is both interesting in its own right and important as a basis for understanding how heat treatment can produce useful changes in the properties of materials. It is certain that this field will continue to be a highlight of materials science research in the future. (Jeff Perkins)

INHIBITING CORROSION AT FERRARA

Corrosion inhibitors are chemical agents added to solutions in order to decrease the corrosion rate of metallic components in the system. Corrosion inhibition is one of the particular areas of expertise at the Corrosion Center "Aldo Dacco" of the University of Ferrara, where the energetic head of the group, Prof. G. Trabanelli, has helped organize the last two meetings of the European Federation of Corrosion series on inhibition. (The 5th European Symposium on Corrosion Inhibitors will be held in Ferrara in September 1980, the same location as the 4th in 1975). Trabanelli is also one of only three professors of corrosion science in Italy (the others are Prof. F. Mazza at the Univ. of Milan and Prof. Maja at the Univ. of Turin). On a recent visit to the laboratory in Ferrara, I discussed their current research activities with Trabanelli and his coworkers.

The group consists of six senior researchers, most of whom have worked together at Ferrara for the last five or six years, and they form a well-integrated team, working on a variety of problems. Within the assortment of topics, however, the central theme is corrosion inhibition and related studies of surface films. Practical objectives that drive the research include reduction of general corrosion rates, stress corrosion cracking, acid cleaning of boilers, corrosion in cooling water systems, etc.

The laboratory facilities are very well designed, efficient, high in quality, and neatly arranged on two floors of a clean, fairly new building on the University campus. Prominent are some very smooth flow loops, one for work with high temperature aqueous solutions (including study of heat transfer effects), and a new one for acid solutions. This impressive new loop has recently been built under the sponsorship of the Ente Nazionale per l'Energia Elettrica (ENEL-Italian National Electricity Board) specifically to study the acid cleaning problem. These loops and the purposes to which they are put have much in common with work carried out at the National Physical Laboratory in the UK, reported here earlier (see *ESN* 32-11:384). The different loops are completely instrumented for conventional electrochemical measurements, and may be set up to monitor electrode potential, polarization resistance, zero-resistance ammetry, galvanic potentials, etc.

Corrosion inhibition, the prominent research topic at the Center, is a means of corrosion control usually not useful except in closed systems where the chemistry of the electrolyte can be maintained. There are various types of inhibitors that can be classified according to the general sort of mechanism they rely on to reduce the corrosion rate. These include absorption-types, poisons, scavengers, and oxidizers. Organic absorption inhibitors, the largest class, are the type emphasized in studies at Ferrara.

The central core of the research program has been a large effort on corrosion inhibition of copper and copper alloys that has been pursued for a number of years, with an emphasis on neutral aqueous solutions of chlorides, sulfates, and nitrates. The tone of this work is to follow the film formation process via such techniques as infrared, visible and ultraviolet spectroscopy, *in situ* photopotential measurements (more on this later), analysis of polarization curves, etc. Inhibition of galvanic corrosion is one of the current areas of interest. For example, as a follow-on to research programs at the Center on the corrosion of copper and copper alloys in aqueous salt solution and on the inhibiting effect of benzimidazole-2-thiol (BIE), the action of this organic compound on the behavior of galvanic couples constituted of Admiralty brass and pure copper or some of its alloys in synthetic seawater has been studied in an experimental loop. In this work, prefilming via BIE is found to be an efficacious means of forming a protective film that can subsequently be maintained by adding very small quantities of inhibitor to the solution.

Another program of study (and a separate flow loop) is devoted to studies of the mechanisms of acid cleaning processes. Acid cleaning of the internal surface of steam generator heat exhanger tubes has now become common practice, with the purpose of restoring optimum conditions of heat exchange by removing surface scales. Because the acid cleaning solution also tends to attack the underlying base metal corrosively, inhibited acid solutions have been developed, and it is this aspect which brings it into the special sphere of interest and expertise held by Trabanelli's group. In mechanistic studies related to the acid cleaning of boilers, the dissolution rates of various types of magnetite (Fe_3O_4, an iron oxide) have been measured by a spectrophotometric technique that reveals the Fe^{+3}/Fe^{+2} ratio as a function of time. Tests have also been performed on model cells comprised of magnetite coupled to steel. The influences of copper and of organic corrosion inhibitors on the dissolution rate of magnetite have been evaluated.

Inhibition of stress corrosion cracking has also been studied for many years by Trabannelli and coworkers, who have been searching for organic substances to inhibit or delay cracking in austenitic stainless steels. Their most recent work on this subject considered various nitrogen-containing compounds in a standard boiling magnesium chloride solution.

To study mechanisms of inhibition, the kinetics of development of thin surface films is of great interest, and the group has perfected a unique method used routinely to study such films *in situ*. The technique consists of measuring the photovoltaic effect, whereby the potential of a material changes when irradiated with light. In the variation usually applied at Ferrara, this is done by monitoring the photopotential as a function of time during a light pulse. The trace obtained can be analyzed to reveal the n or p semiconducting properties of the surface films. This is of interest because the corrosion behavior of the underlying metal is quite sensitive to the defect structure of the oxide. Thus, for example, surface products with prominent n-type characteristics, owing to their electrical conductivity, facilitate the occurrence of cathodic reduction processes. The correlation between the semiconducting properties and photopotentials lies in the fact that negative photopotentials correspond to n-type films, positive to p-type.

This *in situ* technique is of great value because although there is a virtual arsenal of techniques that can be applied to study the nature, composition, structure, and thickness of corrosion films, including various spectroscopic methods, optical and electron microscopy, ellipsometry, and chemical and electrochemical methods, etc., almost all can be used on films only <u>after</u> corrosive exposure as the corrosive environment would otherwise interfere with the measurements. This obviously leads to the possibility that the as-examined film is not the same as it was before removal from the environment. Therefore, *in situ* techniques for film characterization are desired, but there are not many of them readily available, especially for the study of corrosion in aqueous solutions. Photopotential measurements are one way of obtaining at least some data that are unquestionably associated with the as-formed film.

The method, originally developed by Russian workers, has been expertly developed by Trabanelli and coworkers and applied to the study of films on metals such as copper, iron, and zinc. In the studies of inhibition of copper alloys, for example, a special photopotential cell is inserted in a small flow loop to allow intermittent evaluation of the surface products. The technique has also been applied to the study of anodic passive films on iron and oxidation products on zinc. The quantitative interpretation of photopotentials is difficult because of their dependence on many unknown parameters, such as the width of the semiconductor energy gap and the thickness of the layer. There are also upper and lower limits on the thickness of the film for which the technique will work. These are problems, of course, which the group at Ferrara are attempting to overcome.

In summary, the Corrosion Center "Aldo Dacco" is a compact, smooth-running, well-equipped center for corrosion studies. The problems studied are well integrated and not so numerous as to exceed the capabilities of the staff. The group emphasizes electrochemical techniques and physical characterizations of corrosion products in their careful experimental work, and over the years have built up a significant resident expertise in the area of mechanisms of corrosion inhibition. (Jeff Perkins)

MECHANICS

LABORATOIRE DE MECANIQUE PHYSIQUE IN BORDEAUX

The Laboratory of Physical Mechanics in Bordeaux, France, was created by the faculty of Science of the University of Bordeaux in 1961 and since that time has developed a program primarily in the mechanics of deformable media. Unfortunately, at the time of my visit the director of the Laboratory, Prof. T. Loudette, was engaged in an important conference but I was graciously received by Prof. F. Joubert, who discussed the research program with me and introduced me to the various research specialists there.

There are basically four programs at the Laboratory; one is in the area of acoustics and vibration, another in the area of corrosion, a third in the area of mechanics of materials, a fourth in the area of transport phenomena.

The program in Mechanics of Materials is directed by Prof. Joubert and is concerned principally with viscoelastic properties of plastics. As one aspect of this, Mme. G. Signoret and M. Alaa Hamdy were engaged in impacting hardened steel surfaces into polyvinyl chloride targets. The surfaces of the targets were flat, but the hardened steel surfaces had radii of curvature varying from 2 mm to infinity. The steel surfaces were mounted on a small vehicle that rode on air bearings along a guide way. The impacting velocities could be varied from 10 to 100 m/sec, and the temperature of the target could be varied. In this test the coefficient of restitution was tabulated for varying target temperature and radius of impacting surface. I was shown a particularly interesting target consisting of a fiber reinforced composite in which the fibers lay in a direction transverse to the impacting projectile direction. Such a properly designed composite of this type should be able to dissipate the impacting energy very efficiently.

Besides an array of quasi-static tension and bending tests involving very low strain rates, there is a facility (currently inactive) to study wave propagation in materials at a frequency range of 1-10 kHz. An air gun facility capable of firing projectiles of up to 500 g in mass and velocities up to 200 m/sec is also available for making penetration tests into materials.

In another test a split Hopkinson pressure bar consisting of two long cylindrical bars designed to impact each other longitudinally is used to test viscoelastic material properties of disks of test material placed between the bars. The test materials disks are very carefully finished, so that the bars contact the faces of the disk in good alignment, and the faces of the disk are furthermore lubricated so that only axial stresses are transmitted to the test specimen. Measurements are then made of incident reflected and transmitted waves on both faces of the specimen. I was shown a specimen of what appeared to be a soft plastic material which when tested under high-

speed impact exhibited a brittle failure. This, of course, is to be expected in a Kelvin-type viscoelastic solid. Work is presently proceeding on tension and torsion analogs to the split Hopkinson pressure bar apparatus.

The acoustics and vibration program laboratory is under the direction of Prof. J. Roux, whose interests are currently in ultrasonic propagation and ultrasonic holography. An interesting experiment in acoustic holography in water was being set up by Dr. B. Hosten. In this experiment, in which the acoustic frequency is 1 MHz, a 256 × 256 transducer array composed of 1 mm × 1 mm capacitor drivers projects a signal, row by row, from the transducer array at a row scan frequency of 4 kHz. The entire array is therefore scanned at a frequency of approximately 16 Hz. The signals received are then processed in real time so that the image of the target can be reconstructed. It is also possible to reconstruct the image at any plane of the target, and with the high target scanning frequency it is possible to scan moving targets. Hosten told me that the research is intended for the area of medical diagnostics. The resolution of this apparatus will be of the order of 2 mm.

In the area of transport phenomena, under the direction of Prof. M. Combarnous, three Benard convection experiments in porous media are underway. In one of these experiments the usual horizontal planes spaced some 6 cm apart and having a driving temperature difference up to 40 K were packed with a porous medium consisting of 2-mm-diam. glass spheres. The horizontal area of this Benard cell is 30 × 60 cm and the net porosity 0.38. Dr. J. Fauveau, who is performing the experiments, also studied the effect of inclining the apparatus to the horizontal, in which case the Benard convection cells had their axes aligned in a down hill direction. Fauveau is also studying Benard convection in the porous medium for the case of spherical annular geometry; in this apparatus the bounding spheres have diameters of 176 mm and 246, respectively. Fauveau noticed that a number of different stable regimes occurred at the same Rayleigh number. He also investigated the stability problem from a theoretical point of view using perturbation theory and Galerkin's method.

In the area of stress corrosion, under the direction of Prof. Mme. M.C. Petit, she and Dr. D.D. Desjordin, are studying stress corrosion and cracking of nuclear reactor grade stainless steels. In this apparatus, steel wire under a constant load is surrounded by magnesium fluoride between an electrode and the test wire. The tests are conducted under varying loads, temperature, potential differences, composition, and work hardening, and the results are compared with experiments of creeping inert media along with corrosion inhibiters being placed in the surrounding solution. Before the test, the wire surface is electropolished in an electrolytic cell with perchloric acid electrolyte. The mechanism of stress corrosion failure can be described in the following terms: The wire is initially covered with an acid film; under extension this film is broken, resulting in concentrated and localized corrosion; these regions of corrosion then form areas of stress concentration and the cracks open further until finally failure occurs.

The last area of activity that I saw at the Laboratory was the study of fracture mechanics, under the direction of Prof. P. Morlier. In this work the plastic zone development in a notched specimen is being studied theoretically using the von Mises failure criterion, and the strength of the bar calculated. The results are being compared with experiments on a number of nickel cobalt molybdenum steels as well some series of aluminum alloys. (Martin Lessen)

MEDICINE

DIAGNOSTIC PULMONARY LAVAGE

The Brompton Chest Hospital in London is an unusual place. As a tertiary care center for chest diseases, it is extraordinary, inasmuch as patients are referred not only from all over the United Kingdom but actually from the entire British Commonwealth. It is an institution where commonplace diseases are unusual, difficult cases abound, and rarities are commonplace. While the neophyte may obtain a skewed picture of the frequency with which various chest diseases occur, there are great advantages in gathering unusual cases under one roof not only for the benefit of the individual patient but for the study of rare entities.

Professor Margaret Turner-Warwick (Director Pulmonary Section, Brompton Chest Hospital) has a special interest in pulmonary interstitial diseases. One of these is cryptogenic fibrosing alveolitis (CFA), known in the US as usual interstitial pneumonia (UIP). This rare disease of unknown etiology causes an inflammatory reaction in the pulmonary interstitium that leads to fibrosis, severe respiratory impairment, and eventual death in the large majority.

Pulmonary lavage was initially employed therapeutically in order to clear the pulmonary air spaces of abnormal material in various diseases such as alveolar proteinosis and cystic fibrosis. A relatively recent development has been the evaluation of pulmonary lavage for diagnostic purposes. Samples of cell populations from normal and diseased lungs are being studied by quantitative (cell count) methods. Currently Turner-Warwick and her coworkers, headed by Dr. P. Haslem, are studying a group of patients with CFA to compare yields of cells obtained from pulmonary lavage with those obtained from biopsy specimens. The biopsy material is evaluated by a semi-quantitative histological method and by quantitative counts of cells extracted from the specimens. The purpose of the extraction study is to establish whether the cells obtained by pulmonary lavage reflect the cell population in the biopsy material or whether the lavage actually contains a majority of cells derived from small airways.

Other patients also undergoing pulmonary lavage are those with sarcoidosis, asbestosis, and various collagen-vascular disorders. All the patients are evaluated by clinical, physiological and radiographic criteria prior to the pulmonary lavage and lung biopsy. Many, particularly those with CFA, are treated with corticosteroids to which some respond and others do not. The lavage technique is also being evaluated as a predictor of responsiveness to steroid therapy.

Pulmonary lavage is noninvasive and essentially nontraumatic for the patient. It is performed through a fiberoptic bronchoscope after premedication with atropine and a topical anesthetic. The tip of the bronchoscope is wedged into the bronchus leading into a specific pulmonary segment and 60 ml aliquots of normal buffered saline are introduced and aspirated. The mean volume introduced is about 450 ml with a range of 300-550 ml. Approximately one-third of the fluid introduced is retrieved for cell count. The lateral basilar segment of the right lower lobe is chosen for all the diagnostic lavages and the same site used for the lung biopsy that follows. Differential counts are made from total counts of 500 cells and electron microscopy is performed on all samples in order to identify the various cell types positively, particularly macrophages. A semi-quantitative histological assessment of each biopsy specimen is made, a portion of the same biopsy minced, and the cells extracted by use of a cytocentrifuge and counted.

Total cell counts from pulmonary lavages vary from 6.1×10^6 to 392.5×10^6 cells, with a mean total cell yield of approximately 65×10^6. Total cell counts were greater in smokers than nonsmokers, with alleged ex-smokers in an intermediate position. A normal macrophage count for smokers approximates 95% of the entire cell count while for nonsmokers it is approximately 80%. In patients with CFA eosinophils and neutrophils and, to a lesser degree, lymphocytes are elevated. In a group of controls no eosinophils were found, while one-half of the patients with CFA have an eosinophil count of over 4%. The data derived thus far suggest that in contrast to the effects of smoking, the number of lymphocytes and eosinophils appear to be related more closely to the presence of pulmonary disease, while the number of neutrophils may be influenced by both smoking and CFA.

A comparison of the methods reveals no correlation between the histological semi-quantitative cell counts and the differential or total cell counts obtained from extraction or from pulmonary lavage. However, there is a reasonably good correlation between the differential cell counts obtained from pulmonary lavage and from the extraction technique. This suggests that pulmonary lavage reflects the cellularity of the peripheral parts of the lung and not only from the small airways of those patients without overt bronchial disease.

As far as the responsiveness to steroid therapy is concerned, there appears to be a trend toward a higher

lymphocyte count associated with a complementary fall in the number of macrophages in steroid responders. This was true in the cell counts derived from pulmonary lavage and the biopsy extractions. There are, in addition, fewer patients with an increased eosinophil count among steroid responders as compared to nonresponders. Cases with an increase in neutrophils and eosinophils often fail to respond to steroids and sometimes deteriorate quite rapidly. Another trend is that cases with an increase in lymphocyte, neutrophil or eosinophil counts seemed to be in a progressive phase of the illness, while patients with relatively few inflammatory cells are probably in a quiescent phase.

CFA is not only difficult to diagnose but presents significant problems in management because the prognosis is quite variable. While diagnostic pulmonary lavage is not a definitive diagnostic test, it has helped in the understanding of this condition and shows several important trends which may prove useful in its management. (Irwin M. Freundlich)

OCEANOGRAPHY

THE LABORATORY OF PHYSICAL AND CHEMICAL OCEANOGRAPHY AT THE UNIVERSITY OF PARIS

The second largest group of physical oceanographers in France is in the laboratory of Physical and Chemical Oceanography, located at the new Pierre and Marie Curie campus of the Univ. of Paris, across an avenue from the larger Laboratory of Physical Oceanography at the Museum of Natural History (*ESN* 33-5:178). This campus is on the left bank of the Seine, on the site of the former Halles aux vins, the historic centuries old grand market of Paris.

The Laboratory of Physical and Chemical Oceanography is world renowned for its research programs in all phases of optical oceanography. It is directed by Professor Alexandre Ivanoff, who has been teaching and carrying out research at the University since 1962. He also holds a half-time professorship in optics at the Ecole Supérieure de Physique at Chimie Industrielles, one of Les Grandes Ecoles (*ESN* 30-8:360), and has taught there since 1947. It is an interesting coincidence that while Ivanoff directs a laboratory at the university named for the Curies, his office at the Ecole Supérieure looks down the courtyard site where the Curies discovered radium and polonium 81 years ago while Pierre Curie was supervisor of the Ecole Supérieure.

The staff of the Laboratory numbers about 30, of whom some are located at a field station on the southern coast of France at Villefranche-sur-Mer, between Nice and Monte Carlo. The Laboratory is funded by grants and contracts with government agencies and to a lesser extent works for industry in much the same proportions and manner as the larger university oceanographic laboratories in the US.

Much of the effort of the individuals of the staff of the laboratory goes into its graduate instruction program, the only comprehensive one in this subject matter in France. In addition to various courses in oceanography, they also teach atmospheric sciences. About sixty graduate students are studying for their "second degree" which follows the Bachelor's Degree. The second degree is roughly equivalent to the non-thesis Masters Degree in the US.

Another average of twenty students are working toward their "third degree." About half of these are majoring in oceanography and the other half in atmospheric science. This degree requires what Ivanoff described as a small thesis, and its requirements are a little less stringent than those for the PhD in the US. An additional twenty students have completed the work for the above two degrees and are engaged in thesis research for their doctorate. Many carry out their thesis research at the oceanographic laboratory of the Museum of Natural History, whose staff members also teach oceanographic courses at the Univ. of Paris.

The research program at the Laboratory of Physical and Chemical Oceanography is divided into four divisions, with some staff members working in more than one. The first division, headed by Dr. A. Morel, who is also director of the Villefranche-sur-Mer field station, is the oldest. It is concerned with the penetration of solar radiation into the sea and the effects of dis-

solved and suspended particulate matter on the spectral distribution of solar radiation at various places and depths in the oceans. This research is supported in part by contracts with CNEXO (the National Center for the Exploitation of the Oceans of the Department of Industry) and the Association for Research and Development of Methods and Processes for Industry.

Much effort has been expended in the design and construction of instruments to measure the amount, spectral distribution, and directional characteristics of solar radiation *in situ* in the sea. The use of these instruments is not only of primary importance to any study of productivity in the oceans but is also becoming a major factor in the now very popular study of the heat budget of near-surface waters. The Laboratory has taken part in a large number of oceanographic research cruises to measure and record light penetration and the various optical properties of the water masses of the world's oceans. The object is to obtain a representative data bank for new systems of classifying and identifying water masses by their optical properties. This is a long standing and difficult problem because its solution requires complementary ancillary measurements of the amount and nature of particulate seston, the concentration and type of phytoplankton pigments, and the spectra of yellow substances derived from terrestrial and marine humic acid.

The CNEXO contract is for developing and testing systems for remote sensing of the chlorophyl content of the surface waters of the ocean. This requires direct spectral measurements of light ascending from the ocean surface up through the atmosphere to the remote sensor. Two prototype instruments for direct *in situ* (in the ocean) or remote sensing have been built. These instruments measure the amount of energy in five narrow wavelength bands in the visible part of the spectrum of solar energy. The hardest problem that has to be solved is to distinguish between the light ascending from the water that has come from beneath the surface (the signal that is desired) and the light from the sun and sky that has been simply reflected upwards from the water surface (the noise). There is also the problem of determining the attenuation of the ascending light caused by absorption and scattering in the atmosphere between the sea surface and the sensor.

To solve the first problem, one of the sensors is put in a water tight case, facing downward, and is placed just below the surface of the water. This gives the required signal, the true spectral measurements of the ascending light. The second instrument is then placed, facing downwards under an airplane that is flown close to the surface under a variety of conditions, e.g. different solar angles, wind speeds, and sea surface conditions. From this the albedo or reflection of light at the surface can be separated from the light ascending through the sea surface. Next the plane is flown at various elevations above the surface to record the attenuation of ascending light and possible spectral changes owing to absorption and scattering in the atmosphere. About a hundred sets of spectra have to be measured in this way. In addition 190 spectra of ascending light have been measured from the satellite EUROSEP-NIMBUS G.

The second division, headed by Dr. C. Copin, is concerned with the chemistry, size distribution, and optical properties of marine particles in suspension. At the present time this division is working up the results of an Indian Ocean cruise and an Antarctic cruise. In both of these regions most of the particulate matter is of biological origin. The Antarctic planktonic biomass consists mostly of the remains of silicous diatoms, with concentrations of silica particles up to 100 times the concentrations found in the Indian Ocean samples. On the other hand, the carbon content of the particulate matter from Antarctic samples is only twice the amount found in the Indian Ocean samples.

Measurements of particulate matter have been made routinely from the CNEXO buoy laboratory BORHA II in the Mediterrean Sea 80 miles south of Marseille. The amount and kind of particulate matter in suspension was remarkably constant with time below a depth of 150 m.

A four-week cruise was made during February and March 1978 between Villefranche-sur-Mer and Corsica, during the spring plankton bloom. In addition to stations where samples were taken at various depths, continuous samples were made at the surface while the vessel was underway. These samples included turbidity, temperature, salinity, chlorophyl content, and the major nutrient salts. Particulate matter in suspension in the sur-

face waters decreased with distance from shore. The object of the cruise was to determine the relationships between the characteristics of the spring bloom and the various environmental parameters that were examined.

Optical equipment for determining the size distribution of the particles in suspension has recently been improved. The threshold of the smallest particles that can be counted has been almost reduced by 50%, from 1.4 to 0.8 µm. The equipment has been used to study a model of the vertical fall of particles in the sea and the relationships between the vertical size distribution and the concentration of light absorbing material in solution. Dr. Copin's group has determined that suspended particle distributions followed a log-normal distribution more closely than the sometimes reported power law distributions.

The third division, headed by Dr. A. Saliot, is working on the organic chemistry of the air-sea interface, the sediments, and marine organisms. This group is determining the flux of marine fatty acids and aromatic hydrocarbons across the sea surface into the air—one source of natural air pollution. They have discovered that the organic matter right on the sea surface differs materially from that in solution in the water below.

This division uses a mass spectrometer to determine precisely the kinds of fatty acids and hydrocarbons in the various species of attached algae in coastal regions. They feel that this study will also help them in the future to investigate the impact on the biological community affected by the oil spilled from the AMOCO CADIZ on the Brittany coast. They want to be able to know exactly which hydrocarbons come from living marine organisms and which are from oil spills of fossil fuels. Part of the study has to do with lipids *in situ* at the water surface and on phytoplanckton and suspended particles.

The division also has the responsibility within the framework of a research agreement with the Centre d'Etudes de Geochimie Marine of the Compagnie Francaise des Pétroles and CNRS (the French equivalent of NSF) to carry out a quantitative analysis of certain stable chemical compounds in the water just above the sediment and the interstitial waters squeezed from the sediments. Up to now 30 studies have been completed. Samples have been taken from the Cariaco Trench in Venezuela, the large mouths of the Amazon, and off Mauritania. These locations were chosen for study because each one has a different kind of environment.

The fourth and last division, headed by Professor J. Chanu, is studying the relationship between conductivity and density in sea water. The laboratory research is conducted by A. Poisson, assisted by Professor J. Lebel from the Univ. of Quebec. J.C. Brun-Cattan set up the polynomial functions for the relationships derived by Poisson. The aim of the work was to establish an equation of state of natural sea water taking into account the variations in the ionic composition that exist in the world's oceans and estuaries. The ionic composition of Standard Sea Water was taken as a reference. Poisson has determined the law relating conductivity and mass/unit volume for diluted Standard Sea Water.

Finally, a word about the architectural style of the buildings of the Pierre and Marie Curie campus, in which the laboratory is located, may be in order. On looking at these buildings, one gets the feelings that they are a stark monument to the absolute terror that rioting students can instill into university administrators. The campus buildings were designed and built shortly after the massive student revolt that took place at the University of Paris in 1968. The style of the architecture is first and foremost "riot resistant." Most of the buildings are built off the ground, supported by stilts or columns without any ground floor. The first floor (second in the US) is much higher above the ground level than normal; just a little higher than a student can throw a brick or paving stone. The areas between and beneath the buildings are paved with grey cement slabs. The entrances to most of the buildings are located in small circular windowless bastions with massive windowless doors leading to stair wells and elevators. The overall somewhat grim effect is enforced by the proclivity of French university students for spraying the walls with massive negative graffiti.

Fortunately, although the buildings cannot be noted for sheer beauty, they have no effect on the excellent work going on inside. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH IN EGYPT

Operations Research has come to Egypt only recently, and has not thus far found very fertile ground there. While Egypt has a fairly vocal professional OR community that is active in international OR affairs, and OR is taught to engineering and commerce (business) students at most of the many universities, it is hard to find actual applications of OR or of systems-type thinking in much of Egyptian industry and government.

There are exceptions, of course, one of which is the OR group at the Institute of National Planning in Nasr City, a section of Cairo a few miles from its center. The group is headed by Alwalid Elshafei, who in accordance with Arab convention is known either as Dr. Shafei or Dr. Elshafei, and to his friends as Alwalid or Walid, the al and el being equivalent dispensable prefixes. He took his doctorate in OR at the Univ. of Birmingham, and at present supervises a group of six professionals, four with PhDs, plus programmers, systems analysts, and clerks. This OR group is part of the "Center of Planning Techniques," one of seven "Planning Centers" into which the Institute of National Planning is divided. (The others are Agriculture, Industry, Regional, Health and Social, Foreign Trade, and General).

The Institute of National Planning is a government body designed to aid various ministries at three levels: the macro level (e.g., input-output analysis for the government's annual plan); sectoral level (e.g.,water resource models); and micro level (e.g., for individual companies). They conduct all studies on contract, obtaining their money from clients whether public or private. And they get the ear of high-level decision makers in most cases to hear their recommendations. The Institute also runs a one-year course on National Planning; students enter this course with a BSc in engineering or economics or equivalent, plus several years of experience. OR is one of the components of this course.

As an example of the kind of study done by the OR group, Elshafei told me of the crop rotation and allocation study that they had done for the agriculture ministry. Egypt has 26 political subdivisions, called governates, and 16 major crops. Because the country has a highly planned society, the government determines which crops will be grown in which governates and when. This becomes a linear programming model for optimal allocation of resources. The yields on the crops differ depending on where they are grown, as do the water and fertilizer requirements. Some of the crops are subsidized, and some, especially cotton, are rigidly controlled. There are upper bounds on the amount of fertilizer and especially the amount of water that is available and lower bounds on the yields of several of the crops. The objective function is to maximize the overall yield measured in money (Egyptian pounds).

This program has actually been run on computers at the Institute on a month-by-month basis. The output has not been literally implemented, and there is indeed considerable question as to whether it should be, since some of the input data is suspect. Nonetheless, certain recommendations from the model have been accepted—for example, that onions should not be grown in lower (Northern) Egypt. There is also follow-up by the experts at the Research Institutes (economists and agricultural specialists—they have no OR specialists). These people talk to the farmers, and the OR people from the Institute for National Planning talk to them, and all of this is fed back into the model.

Elshafei is representative from the ORSE (Operations Research Society of Egypt) to the International Federation of Operations Research Societies. The president of ORSE is General Halloudah of the Egyptian Army, who took his doctorate at Brno in Czechoslovakia. He assured me that OR is being extensively utilized in the Army, but declined on security grounds to give me any details. The secretary of the ORSE is I.S. Niazy, a Lt. Col. in the Egyptian Navy (sic) who works under Halloudah, and who is completing a PhD at the Statistical Institute of the University of Cairo. The ORSE has almost 200 dues-paying members, but only a comparatively small number of these are active. The Society holds meetings and gives short courses, but does not at this time publish a journal.

As stated above, most universities teach OR, but in many cases there is a shortage of qualified instructors.

For example, at the Univ. of Alexandria, all undergraduates in the School of Commerce take a full year of OR in their 4th (final) year; and there is an additional OR course for all MSc students in the School. These courses are taught in the Department of Management, whose head, Prof. Adel Hassan (PhD in personnel management at Louisiana State) told me that they have sent several students abroad to get PhDs in OR, but until their return, they do the best they can with people from other fields. Some of these courses are taught by an instructor borrowed from the engineering school, namely Prof. Ali El Ashram of the Production Engineering Department, who boasted to me that while he is not a member of the Operations Research Society of Egypt, he was a founding member of the Egyptian Welding Society. The other OR courses in the commerce school are taught by Dr. El Hanawi, who teaches finance, and by two accounting instructors: Drs. Ahmed Ragab and Aly Abbou El Hassan. As all graduate students and undergraduates in engineering can be assumed to comprehend English, their courses use the usual American textbooks; but the same competence cannot be assumed for Commerce undergraduates. Each of the above three instructors have therefore written a book in Arabic on operations research, although I gather that these books are mostly taken from American texts and that some are really just printed lecture notes. In the Engineering School, other departments besides Production Engineering also teach OR, while still others send their students to OR courses in the Computer Science and Mathematics Departments.

As another example, at Cairo Univ. OR is taught in several schools. At the Statistical Institute, they give four "diplomas," equivalent to masters degrees, to students all of whom have full-time jobs and take courses in the evenings. They award about 40 of these a year in OR, together with 75 in Computer Science, 120 in Statistics, and 25 in Demography. Here the OR instructors seem highly qualified. Among those I met were Sammy Akabaoui (that is how he told me his name—I assume that it is an Anglicization) who took his doctorate at City Univ. in London; Said Ashour, PhD from Univ. of Iowa; and Ibrahim Faraq and Shafeek Iskander, who took PhDs from different schools in the Univ. of Manchester.

All of the Institute's students are well qualified in math before entering, and their courses include the standard mathematical techniques of OR. There are also projects, similar to those in the British MSc in OR (see *ESN* 32-12:428), except that each is done by moderately large groups of students (typically 5), and there is generally no attempt to implement the students' solution to a real problem. Students from such a program would appear to be well qualified, but, as stated above, there are few OR jobs in Egypt, and so not many of the graduates actually practice OR. The Institute also awards a few doctorates in statistics, all to part-time students.

As indicated previously in *ESN* 30-9:405, wages for professionals in universities and in government organizations in Egypt tend to be abominably low, and most of the OR people whom I met have a second job that supports them. For example, Hassan El-Ghobary is a most impressive man who took his doctorate in OR at the Univ. of Cairo. He is a Lt. Col. in the Army and one of the 25-man staff assigned to Halloudah. He also teaches courses in network analysis and in modeling at the Institute of Statistics of the Univ. of Cairo and courses in production planning and operations research at Ain-Shams Univ. He presented a paper on "Simulation Applied to Production Lines" at the recent Second Conference on Large-Scale Systems at the Univ. of Waterloo in Canada.

Those few OR people who work in industry make decent wages. With the rapid changes that are taking place in Egyptian society, I would expect OR to become increasingly important there. (Robert E. Machol)

EURO III

The International Federation of Operations Research Societies was formed in 1957 by the US, the UK, and France. Other countries have subsequently joined, and there are, as of this writing, 33 members, each a national OR Society. A few years ago the then President of the Federation, Arne Jensen of Denmark, suggested that because there were now so many national members, it might be useful to have regional federations that could carry on professional activities.

Nothing has come of this suggestion in Latin America, the Pacific, or Asia, but the "Association of European Operational Research Societies within IFORS" has been extraordinarily successful. It held its first meeting in January 1975, and subsequently established an excellent and prestigious journal (*European Journal of Operational Research*, now in its third volume and producing 6 issues a year). The Association sponsors numerous active and effective working groups and has just finished holding EURO III, it's third meeting.

First some statistics of the meeting which was held in Amsterdam, 9-11 April 1979. There were approximately 500 attendees, which is slightly more than EURO II. But EURO II was held in December 1976, in Stockholm, and Amsterdam in April is surely more attractive than Stockholm in December. (In fact, it was even more attractive than anticipated after an unusually severe winter, Amsterdam had half a week of warm, sunny spring just in time for this conference, before settling back to more typical and less pleasant weather.) While well over half the attendees at Stockholm were Swedes, much less than half the attendees at Amsterdam were Dutch. There were 276 papers from 25 countries scheduled. A rather larger than usual fraction of these were not given because the speaker failed to appear (including the only scheduled Soviet speaker and attendee); but a comparable number of late contributed papers made the total number actually presented similar to the above. There were plenary sessions Monday morning and Wednesday afternoon, and on the other two mornings and afternoons there were two sessions each (total eight), in each of ten parallel streams. In each session there were three papers, so almost 240 papers were presented ("almost," because even after rescheduling a few authors failed to appear), with others being given in "Poster Sessions" in which each author had a softboard suitable for posters or flip charts, and a few seats in front, and made formal and/or informal presentations to whomever showed up. Mostly, a paper was relegated to a Poster Session if it had been submitted late or if the author wished to present two papers, but I believe one or two were scheduled there because the abstracts appeared to be of low quality.

Each of the ten streams was supposed to have a theme that carried through the three days, with all its sessions being held in the same room and with like papers being grouped in a single session; but, of course, this sort of thing meets with varying success. The mathematical programming stream was entirely on mathematical programming, with individual sessions on integer programming, dynamic programming, and the like; but the session which I chaired, nominally on "infrastructure" in the stream on "Public Sector," had two of its three papers changed, and one of the substitutes was on purchasing. This was a fascinating paper, but it had very little to do with either infrastructure or the public sector.

The language of the conference was English. That this was the exclusive language used in everything except some private conversations is a remarkable tribute to the linguistic capabilities of the Europeans, since English is the native tongue only of the UK and Ireland, of all the countries represented there. Presumably there is some bias in the sampling—*those* who were not comfortably fluent in English did not come to this meeting—but the almost nonexistent accents of the majority of the delegates, and their ability to carry on technical conversations in English, was admirable as well as surprising.

There are 17 or 18 member countries in EURO, with Austria, Yugoslavia, and Israel having been admitted at this meeting. Because of some doubt as to whether Israel is in Europe or Asia, it was admitted as an associate member (hence, 17 or 18); but since the Egyptians have now indicated their intention to apply formally, and since Egypt's professional interests are as obviously in Europe as their physical presence is in Africa, it seems probable that both Israel and Egypt will be admitted as full members shortly. Furthermore, other socialist countries may now apply. The other 15 current members are: Belgium, Denmark, Finland, France, Greece, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, West Germany, and the UK.

It is difficult to assess such a conference. As compared to typical American conferences (say the national meetings of ORSA and TIMS), I found more uniform attendance (as distinguished from heavy attendance at some sessions and lighter at others) and better at-

tendance, particularly in the early sessions (9:00 a.m.). Session hopping was particularly efficient, because each paper in each session was held to exactly 30 minutes including questioning. There were, of course, a lot of good papers and a lot which were not so good. Most of the authors seem to have done their homework, and I saw no examples of illegible visual aids, or desperate struggles between a long-winded author and a responsible session chairman. The mix between theory and practice was, I am told, about the same as at EURO I and II, with perhaps a slight increase in the theory; but it seemed to me that there were more applications here than I would have found at a typical ORSA/TIMS meeting.

For those wishing to have more information, the program, including the abstracts of the 276 papers and the addresses of their authors, is available from the conference chairman, Dr. C.B. Tilanus, University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands. There will be no proceedings, but submission of papers from the conference to the *European Journal of Operational Research* is being encouraged, and it is anticipated that there will be two or three issues of the journal devoted exclusively to such papers.

The principal address at the opening plenary session was given by G. Zoutendijk. Best known to the OR community for the book *Mathematical Programming Methods* that he wrote while a Professor at the University of Leiden, he opened his address by pointing out that he has really been away from the OR scene for four years now—ever since he was elected a member of the Dutch parliament. (Thus far, no member of the corresponding American OR community has been elected to Congress.) He was interested in how public decisions are made and should be made. He asserted that better knowledge of dangers and promises of technology is desirable; that important decisions require more information and more time for public decision; that public decision should be better organized; that better information systems can strengthen parliamentary control; that new checks and balances are required; that international cooperation is very important; and that OR people should be aware of their social responsibility.

The principal speaker in the final plenary session was Rolfe Tomlinson [formerly head of OR at the British Coal Board, formerly President of the Operational Research Society (of the United Kingdom), and now at the International Institute for Applied Systems Analysis in Laxenberg, Austria]. He discussed several misconceptions that are particularly dangerous because they are partly true, namely: that models are central to OR; that problems can be defined uniquely and invariantly; that models represent reality; that OR is problem solving; that tactics and strategy should be treated differently; that only mathematics can be intellectually rigorous; and that the OR man (or OR team) is an island.

While it is clearly not possible to summarize all the technical papers in the parallel sessions, following are brief reports on a few of the many interesting ones:

S. Walukiewicz (Systems Research Institute, Warsaw, Poland) talked on duality in integer programming. While duals exist to integer programming problems, the important properties of the dual in linear programming do not in general obtain; thus, the complementarity principle of linear programming (that either a constraint has no slack or the corresponding dual variable is zero) does not hold; and the optimal values of the dual variables do not have the economic interpretation (as shadow prices) which they have in linear programming. Walukiewicz reviewed various methods of constructing shadow prices in integer programming problems and then showed how to rotate constraints to reduce the duality gap to a minimum. If this minimum is zero, then complementarity holds and the shadow prices have their usual economic interpretation.

Because there are so many papers on pattern recognition and so few good applications, it was a pleasure to hear Giacomo Patrizi (Universitá degli Studi di Calabria, Arcavacata di Rende, Italy) talk about a computerized trademark search system for the European Economic Community. It is obviously easy to search for identity or near-identity in word sets, but the problem is to search existing trademarks so that an application can be refused if a "similar" one exists. There have, of course, been many judicial decisions, and these were used as the training sample to instruct the computer on examples of pairs which were and were not similar; the system was then tested (successfully) against the file

of registered trademarks for a number of applications.

Göran Bergendahl (Univ. of Göteborg) used a network model to minimize the costs of international capital transfers for a multinational company. Such transfers are expensive both because of overhead and other administrative costs, and because of the float during the transfer time (i.e., lost interest). Transactions can be pooled with those going in the opposite direction, or even on a multilateral basis, but such pooling is subject to constraints—on time when payment is required, and the like. In the network, a node represents a certain subsidiary at a certain time, with some nodes being sinks and others sources, and with losses associated with transactions. The objective function is maximization of the total funds available at a terminal node representing the time horizon.

Dominique de Werra (Ecole Polytechnique Fédérale de Lausanne, Switzerland) used graph theory to optimize scheduling of sports events, in particular, spreading the home and away games of each team as much as possible throughout the season.

A.A. Sissouras (Univ. of Patras, Greece) utilized simulation to determine the total number of beds in a coronary care unit. Too many beds results in excessive cost; too few results in discharging patients from the intensive care unit prematurely. Unless one can find some common measure of effectiveness (units of money equivalent to a unit of time of premature discharge)—which cannot be done—conventional optimization techniques are not applicable; but utilizing the simulation approach permits the introduction of subjective opinion based on medical knowledge into the operational criteria.

B.G. Kingsman (Univ. of Lancaster, UK) presented "Operational Research in Purchasing." More than 50% of the total product cost in the average company is spent on materials and supplies from outside the company, yet purchasing has received little attention from OR. Classical stock control models fail to take account of practical aspects, especially inflation. Where materials are partially substitutable, blending models are appropriate. The great fluctuations in the prices of raw materials mean that purchasing policies for such materials can be among the most important decisions made by management—and OR has something to contribute to forecasting such prices.

In the same session, Uri Shamir (the Technion, Haifa, Israel) described applications of OR to Israel's water sector, including both development and allocation; and Charles ReVelle (Johns Hopkins Univ., Baltimore, MD) described a wide variety of models for location of emergency facilities (fire stations and ambulances). In another session on government, Keith Howard (Univ. of Bradford, UK) described the application of modeling to local governments, with specific emphasis on experience in a small Welsh community. J.K. Pihlatie (Ministry of Finance, Helsinki, Finland) attempted to explain why, in spite of success in traditional OR application areas, there has been a conspicuous lack of successful models at the agency or ministry level in Finland.

There were a number of methodological papers investigating the structure of OR. One of the most interesting of these was presented by Jonathon Rosenhead (London School of Economics, UK), who generally takes a humanistic view of operations research. He stated, for example, that "a survey of OR investigations in the area of urban planning supports the case that the mainstream OR contribution does violence to the nature of the system under study"; "aspects of the social world are subject to wholesale quantification, with resulting distortion"; and "project definition and execution reinforce the scientization of political debate." An intentionally controversial document, I found his presentation, entitled "Operational Research in Urban Planning," one of the most stimulating of the entire conference (which is not to say that I agree with all of it).

In the future it is intended to hold one of these conferences in each year in which IFORS is not holding its triennial conference. Thus, EURO IV is scheduled for 22-25 July 1980, in Cambridge, England, with Maurice Shutler of the Price Commission, London, as General Chairman and J.P. Brans (Univ. of Brussels) as Program Chairman. EURO V will not occur until 1982, because in 1981 IFORS will hold a meeting (in Hamburg, Germany). It appears that these EURO meetings will continue for some time to be the best and most important operational research meetings in the European area. (Robert E. Machol)

RADIOGRAPHY

RADIOGRAPHIC PALEONTOLOGY: THE WORK OF WILHELM STÜRMER

Doctor of Natural Sciences and Doctor of Philosophy, Professor of Physics at the Univ. of Erlangen, Professor of Physics at the Univ. of Mainz, Honorary Professor of Physics at the Univ. of Rhode Island, one of the Directors of Research and Development of the Medical Division of the Siemens Company—physicist, chemist, mathematician, linguist, musician, and paleontologist—Wilhelm Stürmer is a man for all scientific seasons. Although he holds the first patent on a solid-state two-layer image amplifier and developed the electroluminescent phosphors used in making instrument panels for the Apollo spacecraft, Stürmer is most widely known and recognized for his work in paleontology. His paleontology, however, is dependent upon his knowledge and use of x-rays. The combination is extraordinary, of Nobel proportions.

Stürmer's home for the last 23 years on the edge of Erlangen in West Germany is an unpretentious house on a quiet street. After graciously collecting me on a Sunday evening at the railroad station in Erlangen, the professor and I made a brief stop at a small, typically German hotel and then proceeded to his home. After disposing of wet raincoats, Stürmer led me into his combination library-laboratory: A room crammed full of books, papers and fossil specimens but dominated by a large semicircular table.

On the table stands an array of microscopes, a video tape recorder, a photographic enlarger, a low-intensity x-ray tube, and just enough space for a stereoscopic scanning electron microscope to be delivered shortly. It is in this room that Stürmer has accomplished much of the work on the fossils he has found, some of which bear his name. The first specimen he showed me was a 55 million year old bat almost perfectly preserved in the rock. All the details of the bat wings and body were easily apparent. The bat and the fossils of other small mammals were discovered imbedded in layers of oil shale just south of Darmstadt. The area is unique, as it was a large prehistoric lake, evidently with a thick oily bottom. Animals coming to drink were caught in the muck and preserved over the centuries in the layers of shale.

At this point the Professor's descriptions were interrupted by Frau Stürmer and the need for dinner. We trudged out into the West German rain and dined a short distance away on Bratwurst and Bavarian Beer. After dinner we returned to the Stürmer workroom, where both the professor and his wife described half a lifetime of paleontological experiences to their fascinated guest until the small hours of the morning.

Between the valleys of the Moselle and the Rhine are additional large deposits of shale previously mined for the well-known "slate roofs" common to European villages. Although the shale is now too expensive for roofs, the area has become priceless for quite another reason. Near the small town of Gemünden, about halfway between Frankfurt and Luxembourg; a huge shale pit has been donated to Stürmer. This pit, which has yielded fossils from the lower Devonian epoch—380 million years old—is of much greater interest to him than the much younger mammal specimens. In this huge pit the shale is now vertical, as what must have been a cataclysmic upheaval turned the previously horizontal shale virtually 90°. During the upheaval the shale bed was crunched in its center and stretched at the periphery, which destroyed the fossils in those sections. However, between the center and the periphery "neutral zones" exist in which the fossils are well preserved. The vertical layers of shale, according to Stürmer, can be split away with ease and the whole pit virtually "read" like pages of a book.

If a section of shale looks "suspicious" and therefore of interest, it is Frau Stürmer's task, at which she is an expert, to split the shale without destroying the fossils. The shale splits rather easily, according to Frau Stürmer, into slices between 5 and 10-mm thick; which then can be readily radiographed. The fossils in the surrounding rock are easily seen with X-rays, as they have taken up pyrite (FeS_2). Immediate x-ray examination is carried out in a van housing fluoroscopic equipment, which enables the Stürmers to examine as many as 10,000

shale specimens per week. Those sections that show fluoroscopic evidence of fossils are then transported to Erlangen for radiographic examination and analysis. Stürmer makes his own radiographic enlargements, exquisitely demonstrating the details of the fossils, while eliminating the grain of the film. Not only has he found previously undescribed fossils from the lower Devonian epoch but has discovered a number of exceptionally well-preserved examples of known specimens that could never have been seen in their entirety by a mechanical preparation. The radiographic details are amazing in their clarity. The x-ray images demonstrate not only the skeletal remains but also the soft tissues of various small animals inbedded in the shale.

The detailed radiographs are made using a 40-cm focal spot to film distance, 30 kV, 25 mA, and an exposure time of 30 to 60 minutes for a 5-mm thick slab of shale. Agfa-Gevaert graphic film (43P) is used with fine-grain developer for 3 to 5 minutes. High resolution radiographs can also be made using a very similar arrangement on Kodak maximum resolution plates. Typical exposure data would be very much the same except for a much longer exposure time of 12-20 hours. By using a photomicroscope, intermediate negatives with a 25-fold magnification can then be made from these radiographs with no significant loss of detail. These magnificent enlargements demonstrate details of the specimens with unsurpassed clarity.

Stürmer's research has attracted students from all over Germany who work with him on the specimens and radiographs while in their graduate and postdoctoral studies in paleontology. An exhibition of his fossil radiographs is in the midst of a worldwide tour. It began last year at the Smithsonian Institution in Washington and then proceeded to Chicago, Kansas City, Los Angeles, New York, Toronto, Buffalo, and Philadelphia before returning to Europe. This exhibition attracted not only crowds of paleontologists but physicists, radiologists, and photographers as well.

The marriage of medicine and physics in the last quarter century has produced the tremendous technological explosion in medical instrumentation that has revolutionized the practice of medicine at all levels. The same is generally true of all the biological sciences, as all have benefited from the applications of new technology. It is, however, rare to find a single individual who has himself acquired excellence in diverse disciplines. The result is often a new philosophy or new insights such as we witnessed with Jacob Bronowski and Carl Sagan, but this is nowhere more evident than in the life and work of Wilhelm Stürmer. (Irwin M. Freundlich)

SYSTEMS SCIENCES

FOURTH INTERNATIONAL CONFERENCE ON STATISTICS COMPUTER SCIENCE AND SOCIAL RESEARCH, CAIRO, 25-29 MARCH 1979

If the above title seems rather broad for a single conference, it is in fact comparatively narrow in relationship to the actual content of the Conference. Consider the following papers, each of which was from a different session: "Spin-parity Assignments of the 206 keV and Other Higher States in ^{187}Re"; "Thermal Resistance Determination of Integrated Circuits"; "Transport Characteristics of the Natural Flow of Liquid Films at Vertical Electrodes"; "Magnetic Saturation in Turbogenerators"; "Performance of Optical Diversity Receivers in Presence of Log-normal Fading"; "On Some Measures of Industrial Concentrations"; "Follow-up of Family Planning Users Among Refugee Women in the Gaza Strip, An Analytical Study"; "A Simple Cohort Model for Educational Planning"; "Studies on Pertinent Factors Governing the Retention and Availability of Soil Moisture"; "Changes in Tomato Plants Metabolism Due to the Infection by Rhizoctonic and Fusarium Root Rot"; "Economics of the Egyptian Pulp and Paper Industry"; "Effect of GA$_3$ on the Activity of A-Amylase in Potato Peels"; "A Study in Working Relationships Between Egyptian Agricultural Extension Agents and the Local Extension Leader."

It appears that the actual policy was to allow essentially any paper on any topic to be included in the Conference on the grounds that there are so few international conferences in Egypt

and scholars have such a small number of opportunities to present their work in this fashion. As is traditional in European meetings, there was a refereeing system for the selection of papers to be presented, but apparently not all papers went through this system.

The languages of the conference were Arabic and English. About 80% of the papers were presented in English and 20% in Arabic, and the title in the program was in the corresponding language; but the remainder of the program, including the subject matter, location, time, and date of each session were printed in Arabic. While Arabic is extraordinarily difficult for a tyro to read (the script is cursive, so it is hard to know where one letter ends and another begins, and there are several forms of each letter), the numbers are extremely easy (*ESN* 30-9:411). Thus, one could find out when the session was held, but it was frustrating finding out where and on what topic. A proceedings in five thick volumes was available at the conference, and included (in the appropriate language) all papers presented by the Egyptian attendees. Several plenary sessions were conducted largely in Arabic. These included the opening ceremony which was held in the building of the Arab Socialist League in the center of town, the closing ceremonies, which were held in the Gezera Club on the left bank (that is, on the far side) of the Nile, and some special ceremonies for the dedication of a new Department of Defense computer center in the suburb of Heliopolos. There was also a plenary session conducted primarily in English in which an honorary degree was awarded to Dr. Luis Alvarez, and another in which he gave an invited paper on radiologic dating, which was first-rate. Alvarez has had a long history of connections with Ain-Shams Univ. He had supervised a project in which cosmic rays were used to determine whether there were any holes or vacant spots in the large pyramids at Giza in which additional tombs might be found (no such holes exist—the pyramids are absolutely solid except for the chambers that have already been discovered).

The bulk of the sessions at the Conference were held at Ain-Shams Univ. in Abbassia, a section of Cairo about half way between the center and the airport, on the right or eastern side of the Nile. The Conference headquarters were located there, and the technical sessions were held in buildings around the campus, some of which were across a main highway.

A session on Information and Control Systems was scheduled for the fourth day of the Conference. It was chaired by Dr. Naim Abou-Taleb, a distinguished scholar from Alexandria Univ. Unfortunately, he had commitments requiring him to go back to Alexandria, so the session was moved from Wednesday morning to Monday morning. Apparently not all the authors were notified of this change, because only three of the seven scheduled papers were given. I heard two of these papers: "An Indirect Approach to the Solution of Free Final Time Optimal Control Problems" by Gamal M. Aly used very sophisticated mathematics, which I was unable to follow. The other, "Hospital Information Systems" by Shahein Ghonaim, was much more elementary, and gave an overview of present Egyptian state of the art in this field.

I also attended a session on education; two of the papers were in Arabic and the other three in English. As I was the only foreigner in this session among some 20 Egyptians, I suggested that I should leave and then the entire session could be conducted in Arabic. However, they pointed out that these three papers had already been written in English and the authors preferred therefore to read them in English. They did move these papers to the beginning of the session, so I was able to leave at the end of those three; the remaining two in Arabic were then given in my absence.

The first paper, "On Analytical Study of the Educational Wastage Problem Based on a Random Sample," by Abd-El-Maksoud, Ibrahim Salama, and Ahmed F. Mustafa was a study of 79 schools containing 10,970 pupils. Wastage occurs by dropping out or repeating a school year. They discovered that 92% of the wastage was dropouts, the remaining 8% being repeaters. If the student drops out after, say, four years of primary school and does not complete the school, the four years are considered wasted; if a student repeats a year, that one year is considered wasted. The percentage of wastage is higher in girls than in boys, and higher in rural areas than urban. These and similar conclusions were associated with levels of statistical significance.

The second paper, "A Set of Indices for the Measurement of the Quality of the Education Process," by A.F. Mustafa, proposed an index for measuring the quality of education subject to the cost of education. It consisted of a group of indices, the first for the Institute (facilities, crowding), the second for the teachers (their number, qualifications, and percentage of absences), the third for the students (their IQs, socio-economic class, number of absences), and so forth. Each index was normalized to a number between 0 and 1, where 1 was best and 0 worst. These indices were then combined into an overall index by a weighted averaging process. For example, the first index, that for the institute, was based on 8 variables and consisted of the weighted average of a number based on the suitability of the buildings (in terms of factors such as sewerage, playground size, library, etc.) and the geometric mean of several ratios including the faculty-student ratio and the support ratio. This geometric mean was suitably normalized before it was averaged with the others. The overall paper seemed like an interesting exercise, but no justification was given either for the form of any of the functions or for any of the parameters such as the weights and the weighted averages.

The third paper "A Simple Cohort Model for Educational Planning" by A.F. Mustafa and M.A. Anwar, fitted predictive functions to the rates at which entering students dropped out or went on to higher levels of education.

At another session, the only paper I heard was "The Feasibility of Utilizing Operations Research in Social Planning" by Abedel-Aziz Mokhtar. I spoke to him after the session. He is assistant professor of social planning at Helwan University in Cairo, and is highly trained in social planning, but is less familiar with operations research. He had a number of ideas for the applications of OR techniques in his field, but to date none of them have been implemented.

On the third day, the Conference split up, half of it going 100 miles north to Alexandria on the Mediterranean Sea and the other half 100 miles east to Ismailia on the Suez Canal. On arrival, each group had about an hour of technical presentations, with the rest of the day being given over to sightseeing.

The organizers of the Conference were Drs. A.E. Sarhan and Sayed M.A. Wahab. Sarhan is a remarkable man who holds several jobs in several places. He is Cultural Attaché for the Egyptian Embassy in London; he is Prof. of Statistics at the Statistical Institute of the Univ. of Cairo; and he is director of a seven-month course in Systems Analysis and Design run every year by UNESCO at Ain-Shams Univ. Wahab has his doctorate from Ain-Shams Univ., although much of his research work (on time series analysis) was done at Uppsala Univ. in Sweden. He is currently Director of the Scientific Computer Center at Ain-Shams.

The Conference had considerable support from both Ain-Shams Univ. and from other nearby universities. For example, the President of the Suez Canal Univ., Dr. Abdul-Megeed Osman, was an active participant, as were Mostafa Bahgat Abdel-Motaal, Dean of the Faculty of Commerce at Asyut Univ., and the deans of Zagizig Univ. and Tanta Univ. These universities are all within about 50 miles of Cairo.

Almost all the attendees at the Conference were Egyptian; the foreigners consisted of one Hungarian, two Americans besides Alvarez and myself, one Scot, four Englishmen, and some Arabs (e.g., from Iraq). One of the Americans was from the National Center for Health Statistics, which had been asked to send a delegate. The other American was connected with Egyptian projects. A number of those who came from abroad to give papers had their way paid by the Egyptian government. There were some fine scholars present and fine papers given, but they appeared to be outweighed by rather pedestrian papers. However, it was possible to attend only a small fraction of all the technical sessions, and it is unfair to judge the entire Conference by those that I did attend. (Robert E. Machol)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

NEWS & NOTES

THE NO DATA CENTER

The Nederlands Centrum Voor Oceanografische Gegvens (Netherlands Center for Oceanographic Data) is physically housed at the Royal Netherlands Meteorological Institute in DeBilt. The present director, Mr. P. Geeders, took over the management of the center in 1978.

This Center is unique in that it does not have any data in storage. An inventory of the location of Dutch oceanographic data is kept on file in a typewriter-size desk computer and is used to locate and exchange actual data which is on file with various other agencies. The potential user writes or calls, asking whether a certain type of data is available and if so where it is located. The computer file is searched and the potential user is immediately informed of the results of the search. The Center also endeavors to improve and standardize formatting for types of data that are compatible to standardization.

Once a year Greeders publishes a booklet entitled "Cruise Programs of Oceanographic Research Vessels in the Netherlands." In it he lists all of the cruises that are planned for the coming calendar year, including: name of ship, dates of cruise period, area of operation, objectives, coded types of observations to be made, responsible agency, chief scientist, and ports of call. He also publishes an annual report on oceanographic activities at all of the Dutch Oceanographic institutions. (Wayne V. Burt)

COLLOQUIUM SPECTROSCOPICUM INTERNATIONALE XXI AND THE 8TH INTERNATIONAL CONFERENCE ON ATOMIC SPECTROSCOPY

During the week of 1-6 July, the Colloquium Spectroscopicum Internationale XXI and the 8th Internationale Conference on Atomic Spectroscopy met in Cambridge, UK. During the opening ceremonies the general chairman (C.M. Bils, UK) pointed out some of the history of the two organizations and the increasing contributions of spectroscopy to analytical chemistry. Welcoming remarks were also made by the Chancellor of Cambridge University, the Mayor of Cambridge, and by Prof. J. Robin of France (representing the conferees and the IUPAC).

There were over 400 papers presented at the meeting, and the subjects included optical emission, x-ray, atomic absorption, inductively coupled plasmas, mass, and electron spectroscopy. Application covered the environmental, general chemical, geological, and metallurgical areas. With nearly 1000 attendees and as many as seven simultaneous sessions it was a very full meeting, but the organizing committee did an excellent job with arrangements and time scheduling so that most of the attendees were able to hear nearly all the papers they were interested in. They had also planned a full social and sports program that left little to be desired.

The joy and enthusiasm of the meeting was broken on Tuesday by the sudden collapse and death of Prof. T. Takeuchi of Japan who had just finished presenting his paper when he suffered a stroke. (L.S. Birks, Naval Research Laboratory, Washington, DC 20375)

PERSONAL

Dr. R.J. Briscoe, Professor of Physiology, Bristol Univ. Medical School, has been appointed to the Jodrell Chair of Physiology, University College, London

Dr. D. Mara, Senior Lecturer, Civil Engineering, Univ. of Dundee, has been appointed to the newly created second Chair of Civil Engineering at the Univ. of Leeds, from 1 October 1979.

ONRL REPORTS

C-3-79 1979 SPRING REVIEW COURSE: PHASE TRANSFORMATION, 4-7 APRIL 1979, YORK, UK by J. Perkins

The proceedings at the conference are reviewed, including papers on all classes of phase transformation, on new methods of research, and on examples of applications. Precepitation, martensitic transformations, order-disorder reactions and other types of phase transformation are included. Other topics include morphological instability in microstructures, phase transformations in ceramics, and the effect of industrial processing on transformations.

R-1-79 THE DEPARTMENT OF OCEANOGRAPHY, UNIVERSITY OF LIVERPOOL by W. Burt

The Department of Oceanography at the University of Liverpool is the oldest of the three oceanography departments in the UK. Its research is largely in physical oceanography and marine analytical chemistry. A full range of courses is offered in physical and chemical oceanography. Students are working for undergraduate honors degrees in oceanography and the MS and PhD degrees.

R-2-79 EUROPEAN FIBRE OPTICS: A COMPLETE REPORT OF THE JUNE 1978 SURVEY by D. Williams, D. Hart, T. Meador, A. Glista, F. Allard (Proprietary information distribution limited to US Government agencies only)

This report documents the findings of a series of visits to industries working on fibre optics technology in Europe. Thirteen companies in five countries were visited. These companies' activities range from limited involvement in component development through entire fibre optics system development and research on all related technologies. A massive effort is represented by the collective activity and investment being dedicated to this emerging technology in Europe. Present and future activities of these companies deserve further evaluation from military research managers who may be planning to make use of fibre optics technology for military applications.

R-3-79 DEVELOPMENTS IN ACOUSTIC TRANSDUCTION IN WESTERN EUROPE by R.J. Bobber

A survey of applied research and development in underwater acoustic transduction in Western Europe reveals a widespread interest in piezopolymers and some potential in fiber optic acoustic sensors. Little else in innovative transductions concepts was found. An electrical charge insertion theory and the production of thick PVF_2 films may each have significant effects on piezopolymer hydrophone development.